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The Analytic Process Model for System Design and Measurement: A Computer-Aided Tool for Analyzing Training Systems and Other Human-Machine Systems

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this model development effort was to provide a uniform, thorough, adaptive and efficient procedure to help derive design specifications and effectiveness measures for any planned or existing human-machine system, and especially for a training system. The present report describes results of almost three years of work, in which the analytic process model (APM) was developed from earlier models, applied in sample fashions to an existing system (the Bradley Infantry Fighting Vehicle) and placed onto an Apple II computer to demonstrate its automated,
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20. Abstract (continued)

interactive potential. The APM guidelines and procedures are also documented here. Recommendations are made for enlarging and completing the model and for its dissemination to Army users. A separate Operations Handbook was issued for the computer-aided APM demonstration system.

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I. EXECUTIVE SUMMARY

This report describes an analytic process model (APM) for systems design and measurement. This model provides a uniform, thorough, adaptive and efficient procedure to derive design specifications and effectiveness measures for any human-machine system, including any training system.

The APM is designed to enable testers, analysts and researchers to define sets (or taxonomies) of system performance requirements, and to translate them into measures and/or design requirements. It forces one to describe the system of interest and its human elements in terms of a more complete set of system-human attributes pertinent to system effectiveness. The general APM is illustrated in Figure 1. An interactive demonstration was developed to illustrate the potential for a computer-aided APM to generate effectiveness measures (Figure 1, Blocks 1, 2 and 4) for training systems in particular. It provides general "menus" of performance items and procedures to help translate those items into appropriate evaluation measures. Work with this demonstration computer-aided model suggests that similar routinized programs can also be developed for other particular kinds of systems (e.g., communication, transportation, weapon, etc.).

This project addresses the problem that testers, analysts and researchers too often use an incorrect, incomplete or inappropriate set of human performance factors in evaluating or specifying a human-machine (e.g., training) system. Those are usually known measures and traditional design choices often selected without adequate consideration of the system <u>qua</u> system. They may not ask the essential questions about system performance and effectiveness or they may provide inadequate answers to these essential questions.. Because no verified analytic process for deriving (or specifying) the optimal measures of a system's performance or effectiveness exists, true assessment needs are difficult to define and the process is relatively haphazard. The typical solution is to test/measure/specify the easy and accessible system points, but not necessarily those that should be addressed. Without having more systematic procedures, people measure or specify what can be counted (e.g., POI hours), or observed (e.g., number of troops trained). They design written tests to assess the learners' rote memories rather than their understanding, and use criteria such as end-of-course tests rather than on-the-job performance. Rarely do people know the relationship between test performance and job performance, or between soldier job performance and unit effectiveness. This results in wasting valuable resources (time, effort, talent, money), failing to provide adequate answers to effectiveness questions, and losing important facts regarding human contributions to system performance. The APM is designed to be a better method for deciding what should be measured, or designed, and how.

The recent development and tryout of the APM were performed within the context of the Bradley Infantry Fighting Vehicle (BIFV) development program, a complex man-machine and training system. The following products have resulted: an outline APM (Figure 1); a detailed STM (Figure 1, Block 1) and associated procedures for deriving dimensions or taxa of system performance;

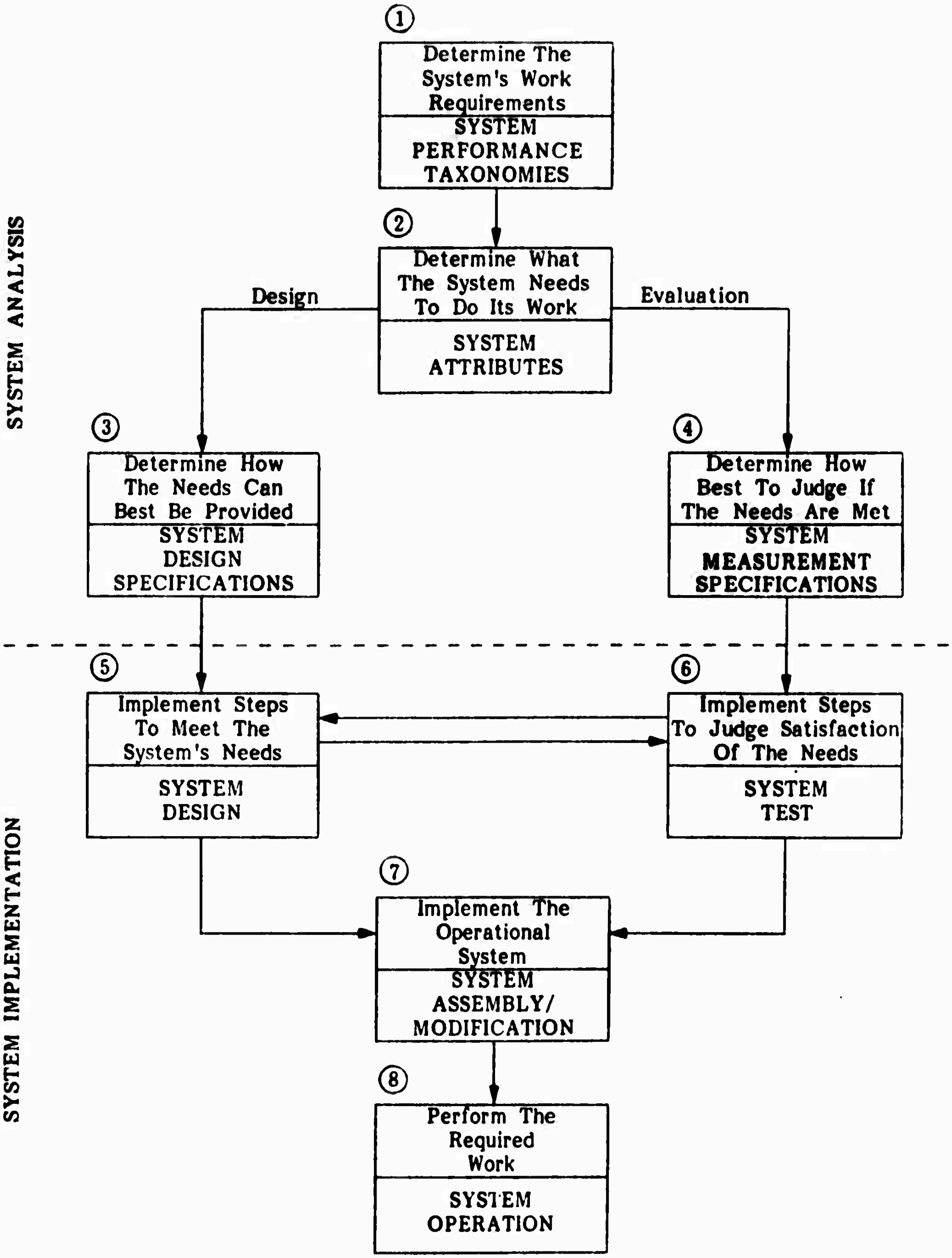


Figure 1. Overview of the APM for System Design and Evaluation

initial procedures for deriving attributes (Figure 1, Block 2), design specifications (Figure 1, Block 3) and measures (Figure 1, Block 4) from the taxa; identification of taxa for the surveillance function of the BIFV; definition of what functional subsystems constitute a training system; partial or, in some cases, complete identification of taxa for the subsystems of the BIFV training system (BIFVTS); and a demonstration computer-aided APM program. Although the sample taxa have been developed for the BIFV, they appear to be generic and applicable to any manned system.

The APM application is illustrated in Figure 2. This shows how an analyst could produce effectiveness measures using the computer-aided model. The procedure consists of branching through a series of nested sets. The analyst chooses from the computer's data base of recommended options or creates new options at each branch. Special instructions and help are available on-line and in an operating manual to guide the analyst through the model. Hard-copy printouts of the selected options are available immediately upon request at key stages of the analytic process. Figure 3 is a sample of such a printout, including a portion of the Figure 2 illustration. The sequential digits in the index numbers of Figure 3 correspond to the analytic items and levels illustrated in Figure 2 (Aspects, Objectives, Functional Purposes, Characteristics, Attributes and Measures, respectively). As seen in Figure 3, attributes and measures can be derived from any of the three analytic levels (Objectives, Functional Purposes or Characteristics). Consequently, zeros can appear in the third (Functional Purposes) or fourth (Characteristics) positions of the index number. The header information and index numbers provide a means for tracing the connection between any selected performance measure and its determining prerequisites. One can thereby insure that all system objectives are addressed by derivative evaluation measures and that all measures are justified.

As described in Chapter IV, the APM compares in several important ways with other models for evaluating or developing training systems and other human-machine systems. For example, it is totally consistent with the general objectives of MIL-H-46855B ("Human Engineering Requirements for Military Systems, Equipment and Facilities"), by providing a general, sequential method by which human-machine systems can be developed in a total systems context and with careful emphasis on the human element. It complements a variety of methods grouped under the generic term Instructional System Development (ISD) by facilitating the front-end analysis of training systems. ISD frequently comes too late to identify some potential training problems, whereas the APM can be applied earlier when such issues as performance goals, mission, objectives, functions, tasks, job analysis, validation and logistics must be first addressed. The broader and earlier analysis provided by the APM can set the stage for the detailed processes associated with ISD. The APM is also complementary to the Early Training Estimation System (ETES). The APM is of special value in facilitating the generation of system and subsystem objectives and the development of performance measures, while ETES is of particular value in evaluations of media and instructional methods. The APM is compatible with various methods for Logistic Support Analysis (LSA), in that earlier estimates of logistics requirements can be prepared with the aid of the APM. Because the APM can be applied to developing systems in which operating parameters are still evolving, it also can be useful for generating

APM Step No.	Analytic Determination To Be Made	Options Selected for this Illustration
1.	Purpose in Applying the APM:	To help evaluate the BIFVTS design subsystem's effectiveness in specifying gunner learner testing.
2.	Application:	Design Specification · Performance Evaluation (Measurement)
3.	System Class:	Communication · Training · Weapon · Transportation
4.	System:	Handgun Training System · BIFVTS · 155-mm FA Training System
5.	Subsystem:	Command · Logistics · Emplacement · Design · Enabling · Delivery
6.	Aspects:	1. Potentialities · 2. Processes · 3. Products · 4. Environment · 5. Constraints
7.	Objectives:	1.2. The subsystem must be capable of: establishing performance objectives.
8.	Functional Purposes:	1.2.1. This subsystem capability allows: stating expected performance and behavior after training.
9.	Characteristics:	1.2.1.1. For this purpose, the system must have the potential for: defining the performance action.
10.	Measurable Attributes:	1.2.1.1.1. To evaluate effectiveness in meeting this characteristic, the following system attribute(s) can be measured: types of BIFV gunner performance actions intended to be defined.
11.	Measures:	1.2.1.1.1.1. This system attribute can be analyzed by comparing the following parameter(s) with established criteria: relevant types of actions not intended to be defined.

Figure 2. Sample Illustration of the Sequential Steps in Applying the APM

Final Summary Report
February 28, 1983
Illustration of Analysis Printout

Measurement Purpose: To evaluate training design subsystem effectiveness in specifying learner testing

System Class: Training[4]
System: Bradley Infantry Fighting Vehicle Training System (BIFVTS)[1]
Subsystem: Design[3]

1.0.0.0.0.0. Potentialities: The system must be capable of:
- 1.1.0.0.0.0. Identifying goals and priorities
  - 1.1.0.0.1.0. Scope of information available concerning BIFVG operations
  - 1.1.0.0.2.0. Staff experience and qualifications in identifying training goals
  - 1.1.0.0.3.0. Planned approach to identify BIFVG training goals
  - 1.1.0.0.4.0. Resources allocated to identifying BIFVG training goals
- 1.1.1.0.0.0. Defining the total scope of learning
  - 1.1.1.0.1.0. Aspects of each gunnery training goal to be defined
  - 1.1.1.0.2.0. Plans for defining the total scope of BIFVG learning
  - 1.1.1.1.0.0. Identifying types of achievements relevant to the intended job
    - 1.1.1.1.1.0. Types or classes of achievement intended to be identified
    - 1.1.1.1.2.0. Plans for identifying all types of BIFVG achievements
- 1.1.2.0.0.0. Stating the ultimate intended outcomes of learning
  - 1.1.2.0.1.0. Elements of ultimate outcomes that are intended to be stated
  - 1.1.2.0.2.0. Intended formats to state ultimate intended outcomes of BIFVG lrng
  - 1.1.2.0.3.0. Plans for stating ultimate intended outcomes
  - 1.1.2.1.0.0. Determining necessary levels of achievement
    - 1.1.2.1.1.0. Elements or factors of necessary levels intended to be determined
    - 1.1.2.1.2.0. Plans for determining necessary levels of BIFVG achievement
  - 1.1.2.2.0.0. Determining existing levels of achievement
    - 1.1.2.2.1.0. Elements of the current levels of achievement intended to be tested
    - 1.1.2.2.2.0. Plans for testing candidates' current levels of BIFVG achievement
- 1.1.4.0.0.0. Establishing a basis for specifying learning objectives
  - 1.1.4.0.1.0. Elements of the basis intended to be established
  - 1.1.4.0.2.0. Plans for establishing the basis for specifying BIFVG perform obj
  - 1.1.4.1.0.0. Insuring availability of a hierarchy/taxonomy of objectives
    - 1.1.4.1.1.0. Goal taxo intended to be employed
    - 1.1.4.1.2.0. Plans for employing the taxo to classify goals for BIFVG training
    - 1.1.4.2.0.0. Stating goals in terms that imply behaviors
      - 1.1.4.2.1.0. Behavioral terminology intended for use in stating BIFVG goals
      - 1.1.4.2.2.0. Intended formats for stating BIFVG training goals
- 1.2.0.0.0.0. Establishing performance objectives
  - 1.2.0.0.1.0. Scope of information availabe concerning BIFVG task
    - 1.2.0.0.1.1. BIFVG required tasks that are known (list & descrb each)
    - 1.2.0.0.1.2. BIFVG required tasks that are unknown to Design Subsystem(list ea)
    - 1.2.0.0.1.3. Tasks that are not reqd of BIFVG but Design Subsys classif as reqd
  - 1.2.0.0.2.0. Staff experience and qualifications in establishing perform objctvs
    - 1.2.0.0.2.1. Revwrs cum ratings of ea Design staff qual to estab trng perf obj
    - 1.2.0.0.2.2. Revwrs overall assessment of total Design staff qual
  - 1.2.0.0.3.0. Planned approach to establishing BIFVG performance objectives
    - 1.2.0.0.3.1. Essential steps missing from plans (list & describe ea)
    - 1.2.0.0.3.2. Inessential steps included in plans (list & describe ea)
    - 1.2.0.0.3.3. Inconsistencies/deficiencies in sequencing steps in plans
    - 1.2.0.0.3.4. Reviewers cum ratings of soundness/workability of plans
  - 1.2.0.0.4.0. Resources allocated to establishing BIFVG performance objectives
    - 1.2.0.0.4.1. % of reqd person-hrs proposed for alloc to establish objectives
    - 1.2.0.0.4.2. % of reqd materials/goods proposed for alloc to establish objctvs
    - 1.2.0.0.4.3. % of reqd support services proposed for alloc to establish objctvs
    - 1.2.0.0.4.4. Ratio of $ proposed to $ needed for establishing objectives
- 1.2.1.0.0.0. Stating expected performance and behavior after training
  - 1.2.1.0.1.0. Elements or factors of gunner abilities intended to be stated
    - 1.2.1.0.1.1. Essential elements of abilities to be incl in stmt of BIFVG ablty

Figure 3. Sample Printout of Analysis Results

early inputs (objectives, parameters, measures) to the Army's Human Resources Test and Evaluation System (HRTES). While the APM provides a measurement framework for the HRTES technique, HRTES extends APM further into the operational testing domain.

Now that a computer-aided demonstration system of the APM is available, Chapter V considers how it can be improved. The demonstration system can now be used to develop evaluation measures for three of the six training subsystems: Design, Enabling and Delivery, but not Command, Logistics or Emplacement (see Appendices A, B and C). It is essential to develop the taxa of subsystem performance items, subsystem attributes and attribute measures for the three remaining training subsystems to use the APM fully for evaluation. Procedural guidelines must be developed for generating design specifications from the performance taxa to use it in developing design specifications. More complete computer "help" instructions must be made available on request. Eventually, the model must include data bases (taxa) for more than training systems: computer assistance should be tailored to communications systems, weapon systems, transportation systems, and many others of interest to particular users. The package could also incorporate a routine for costing guidelines to aid in early evaluation decisions. Clearly, if these capabilities are added to the computer-aided APM, it will require a computer of significantly greater capacity than the present Apple II Plus which barely contains the sample demonstration program.

II. THE ANALYTIC PROCESS MODEL

The APM is a conceptual framework for systematizing the process of designing and evaluating human-machine systems. Impetus for APM development is the experience that system design and evaluation often proceed haphazardly. Design and measurement decisions are frequently formulated out of familiar practice, without due consideration of new approaches that may be preferable. Conversely, designers and evaluators sometimes adopt emerging technology or methods because they are novel, without adequate regard for what is best suited to the application at hand. In either case, the system may be built and/or tested incorrectly, incompletely or inappropriately. This results in misleading evaluative findings, and systems that do not work as well as they should.

The fundamental concept behind the APM is that the haphazard design and evaluation typically begin with a failure to consider fully the system's intended work. That is, designers often start to build systems, and evaluators often start to test them, without a clear understanding of what the systems are supposed to do, and where, when, why and how they are supposed to do it. The APM is designed to remind (or force) designers and evaluators to consider all relevant factors.

A. The APM Concept and Definitions

Based on the original work of Finley et al. (1975, 1976) and extended by Bloom et al. (1981, 1982), a four-stage functional sequence was defined as the top level (or macroscopic) outline of the APM. This is illustrated in Figure 4, with a cross-reference to the blocks of Figure 1.

Stage 1, the contextual stage, is the Systems Taxonomy Model (STM) as initially defined by Finley et al. (1975). It is an organized conceptual framework and a set of data bases and guidelines that assist an analyst in determining what the system of interest is supposed to do and why, how, where and under what circumstances it is supposed to do it. The STM is a model for taxonomization since it provides a means of generating dimensions which would be taxa in that they could be used for systems classification and as generic terms for analysis to develop measures of effectiveness and performance. The STM has three dimensions:

- Aspects of system performance (of which there are five).
- Levels of system description (of which there are three).
- System hierarchical structure (which can contain any number of suprasystems, subsystems and collateral systems).

Stage 2, the focal stage, includes analytic procedures for translating the required work into corresponding system attributes. This stage also includes procedures for determining how to insure the presence of those attributes, and for determining whether they are present to the appropriate degree. The outputs of Stage 2 are the basic tools of a system evaluation application (measures of performance/effectiveness) and/or of a system design application (design specifications).

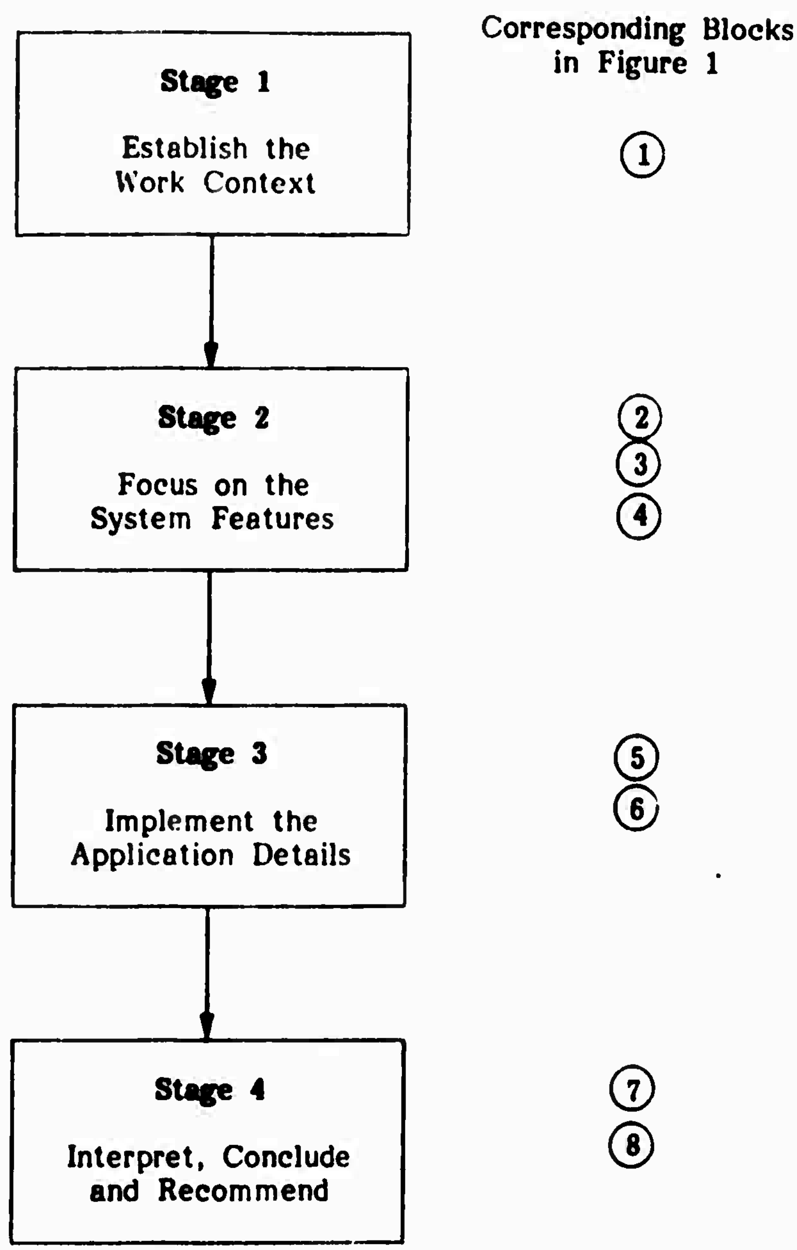


Figure 4. Four Stages of the APM

Stage 3, the implementation stage, consists of methodology for employing the application tools. For a design application, Stage 3 is where the system is actually built, in accordance with specifications. For an evaluation application, Stage 3 is where the system is actually tested, using the measures.

Stage 4, the interpretation stage, includes analytic procedures for determining whether the system satisfies its work requirements and, when deficiencies exist, for determining how the system must be modified to correct the deficiencies.

To date, the key concepts have been developed for Stages 1 and 2. They are described in the following paragraphs.

1. Aspects of System Performance

A system's work is broadly defined by what it is supposed to do and where it is supposed to do it. To support design or evaluation, the "what" of performance can be divided into three mutually exclusive classes, or aspects:

- Performance potentialities--the capabilities for doing work that the system is supposed to possess;

- Performance processes--the activities that the system is supposed to carry out;

- Performance products--the outputs that the system is supposed to deliver.

A system could fail at any of these three aspects of performance. It could simply not have the prerequisite abilities needed to get its job done; it might have the ability, but fail to implement the necessary procedures; it might have the ability and carry out the procedures, but fail to deliver the required goods and services in the quantity and quality needed. Too often, system evaluators concern themselves only with the output, or product, aspect of system performance. But if the product is deficient, no corrective action can be taken unless the evaluation can diagnose the process and potential performance to uncover the root cause of the failure.

The "where" of performance similarly subdivides into two mutually exclusive aspects:

- Performance environment--the naturally occurring set of conditions and circumstances under which the system must provide its capabilities, carry out its processes, and deliver its products.

- Performance constraints--the man-made or artificial limiting factors that apply to the system's potential, process and product performance.

System designers and evaluators always must consider the real world, where the system actually will be used. It isn't good enough that a system can provide its required abilities, carry out its processes and deliver its products

under the most favorable circumstances, or without regard for cost, safety, time, or other considerations. Performance under actual operational conditions and in full compliance with all necessary restrictions is demanded of every system.

2. Levels of System Description

Three levels of system description are defined:

- Objectives
- Functional Purposes
- Characteristics

The "what" and "where" of system performance provide a sterile or abstract view of a system's work. It is a view of work as something that merely is, without regard for its purpose. This is the Objectives-level of work definition, i.e., the performance elements are defined as objects or ends in themselves. Quite different types of systems may have similar work requirements at the objectives-level of description. The process known as "Task Analysis," for example, is required in: tool design systems, training development systems, personnel evaluation and management systems, and many others.

But systems do not perform work merely for its own sake. There always is a purpose behind a system's work, a function to which each work element is to be applied. Otherwise, the work really is not required. Furthermore, if the system works to accomplish purposes, there must be a method to its work. That is, it must approach its work requirements in characteristic ways which insure that the purposes will be met. These observations lead to definition of two other levels of system description. The Functional Purposes-level corresponds to the "why" of performance: the reasons for the existence of objectives-level work requirements. The Characteristics-level corresponds to the "how" of performance: the characteristic ways in which the system provides its potentialities, carries out its processes, and delivers its products to insure that their purposes are met.

3. Interaction of the First Two Dimensions: Taxa of System Performance

The five aspects of system performance interact with the three levels of system description to form a fifteen-cell matrix. Each cell represents a particular taxonomy of work requirements, each member of which is a particular taxon or dimension of work. As an example, Figure 5 arrays the work requirements taxonomies for the Carrier Team Subsystem of the Bradley Infantry Fighting Vehicle, and exhibits sample member taxa for each cell.

Within each column in Figure 5, the member taxa are hierarchically linked from cell to cell. In the topmost cells, general statements of the "what" and "where" of performance are found. For example, the system is supposed to have the potential for "providing surveillance" (taxon 1.1), and is supposed to do so in a "rolling terrain" environment (taxon 4.1). In the cells of the middle row, the purposes behind the required work are stated. The reasons for the potential of "providing surveillance" include having the capabilities of

ASPECTS OF SYSTEM PERFORMANCE

LEVELS OF SYSTEM DESCRIPTION	Potentialities	Processes	Products	Environment	Constraints
Objectives	1.1 Providing surveillance 1.2 Conducting weapons fire etc.	2.1 Carry out overwatch bounds 2.2 Engaged identified threats etc.	3.1 Squad bounds 3.2 Threat detections etc.	4.1 Rolling terrain etc.	5.1 Communication constraints etc.
Functional Purposes	1.1.1 Conducting sector surveillance 1.1.2 Detecting targets 1.1.3 Acquiring targets etc.	2.1.1 Bound to secure forward position 2.1.2 Enable platoon movement etc.	3.2.1 Enemies located 3.2.2 Intelligence information provided etc.	4.1.1 Hills 4.1.2 Valleys etc.	5.1.1. Communication security 5.1.2. Contact information exchange etc.
Characteristics	1.1.2.1 Unaided visual target detection capability 1.1.2.2 Aided visual target detection capability 1.1.2.3 Infrared sensor target detection capability etc.	2.1.2.1 Assess security of bound position 2.1.2.2 Communicate security to overwatch element etc.	3.2.2.1 Information regarding what was observed 3.2.2.2 Information regarding how many were observed etc.	4.1.1.1 Maximum upslope of eight degrees etc.	5.1.1.1 Avoid radio transmission prior to contact 5.1.1.2 Maintain light and noise discipline etc.

Figure 5. Sample 2-Dimensional STM for the Bradley Infantry Fighting Vehicle (Carrier Team Subsystem)

"conducting sector surveillance" (taxon 1.1.1), "detecting targets" (1.1.2), "acquiring targets" (1.1.3), and possibly other purposes. Further, the system is required to be able to achieve those purposes while operating on hills (4.1.1) and in valleys (4.1.2). The decimal numeric notation links the various functional-purposes-level taxa with the individual objectives-level taxon they support. Taxa 1.1.1, 1.1.2, and 1.1.3 all support or "descend from" taxon 1.1.

The cells of the bottom row state how each purpose is to be satisfied. For example, the capability of "detecting targets" will be met by providing the potentials for "unaided visual target detection" (1.1.2.1), "aided visual target detection" (1.1.2.2), "infrared sensor target detection" (1.1.2.3), and perhaps through other capabilities as well. The decimal notation traces the vertical path from cell to cell. Thus, characteristics-level taxon 1.1.2.3 descends from functional-purposes taxon 1.1.2, which in turn descends from objectives taxon 1.1.

As Figure 5 illustrates, the matrix resulting from the interaction of the first two dimensions of the STM provides a framework for organizing:

- The basic work requirements for which the system is intended, including its potential, process and product aspects and the natural and man-made factors impeding those aspects;
- The purposes behind each work requirement, and the environmental and constraining components that bear on those purposes;
- The ways in which the system is supposed to achieve its purposes, and the factors that may impede those ways.

4. System Hierarchical Structure: The Third Dimension of the STM

Systems seldom work in isolation. Usually they interact with other systems, so that the work they do influences, and is affected by, what other systems do. Designers and evaluators need to account for these other interacting systems so that all of the requirements of the system of interest may be identified and so that appropriate interfaces may be designed and appropriate evaluation controls may be established. Three kinds of interacting systems can exist:

- Larger systems, of which the system of interest is a part, and superior systems exercising command and control over the system of interest. Collectively, these larger, superior systems are termed suprasystems. It is often at the suprasystem level that the work requirements of a system of interest are established.
- Smaller systems wholly contained within the system of interest, and systems over which the system of interest exercises command and control. Such smaller, subservient entities are called subsystems. The ability of a system to satisfy its work requirements often depends on the subsystems' abilities to perform as they are supposed to do.

- Systems that exist and operate on the same level of command and control as does the system of interest, and with which the system of interest shares resources or exchanges inputs and outputs. These equal ranking, interacting systems are termed collateral systems. A system of interest must be designed to interface compatibly with its collateral systems.

Figure 6 illustrates the concept of system hierarchical structure in the context of the Bradley Infantry Fighting Vehicle. The BIFV is shown as subservient to one suprasystem, namely, the mechanized infantry platoon of which the individual vehicle system is a member squad. It has two subsystems, namely, the Carrier Team Unit (Track Commander, Gunner, Driver, the vehicle control apparatus, the vehicle-mounted weapons, etc.), and the Crew Compartment Team (Firing port weapons and firing port weapon operators). Four collateral systems are shown. Three of these are the other individual fighting-vehicle systems that make up the platoon (including the particular vehicle that happens to house the platoon headquarters). Another collateral system is the enemy armored-vehicle system, i.e., the threat. In the operational environment, the BIFV derives its work requirements from the platoon's orders, translates those requirements into the corresponding responsibilities of its two subsystems, and carries out its duties in concert with (and without interfering with) its sister squads. And undeniably, it carries out its duties in concert with the threat system, since those duties include detecting, acquiring, identifying, tracking, engaging, and neutralizing or destroying the threat. The relationship between the BIFV and the threat is certainly antagonistic, but equally certainly interactive and thus collateral. If the BIFV is not designed with the threat's capabilities and work requirements in mind, the BIFV likely will fail to achieve its purposes. In an engagement situation, the outcome may depend not only on how well the BIFV performs its intended work, but also on how well the threat does its.

5. Summary of the 3-Dimensional STM

To recapitulate briefly, the STM is the first stage of the APM. It is the stage at which a system's work requirements are identified and organized so that they will be fully considered in the design and evaluation of that system. Identification of the work requirements demands that the analyst examine not only the system itself, but also its operational environment, practical constraints, and the performance factors of other systems with which it interacts. In organizing "what" work the system is supposed to accomplish, it is necessary to consider not only the products, goods or services to be delivered, but also the processes intended to lead to those products and the potentialities needed to carry out those processes effectively. Further, for each element of required work, it is necessary to identify all of the purposes, or reasons, why the work is needed, and exactly how those purposes are to be achieved. Finally, each system of interest must be examined in the context of the hierarchical system structure in which it is necessarily embedded--the supra-, sub- and collateral systems.

6. Guidelines for Identifying Dimensions/Taxa of System Performance

Through experience gained in a series of trial applications of the APM concept, guidelines have evolved for identifying a system's work requirements within each cell representing interaction of a particular aspect of

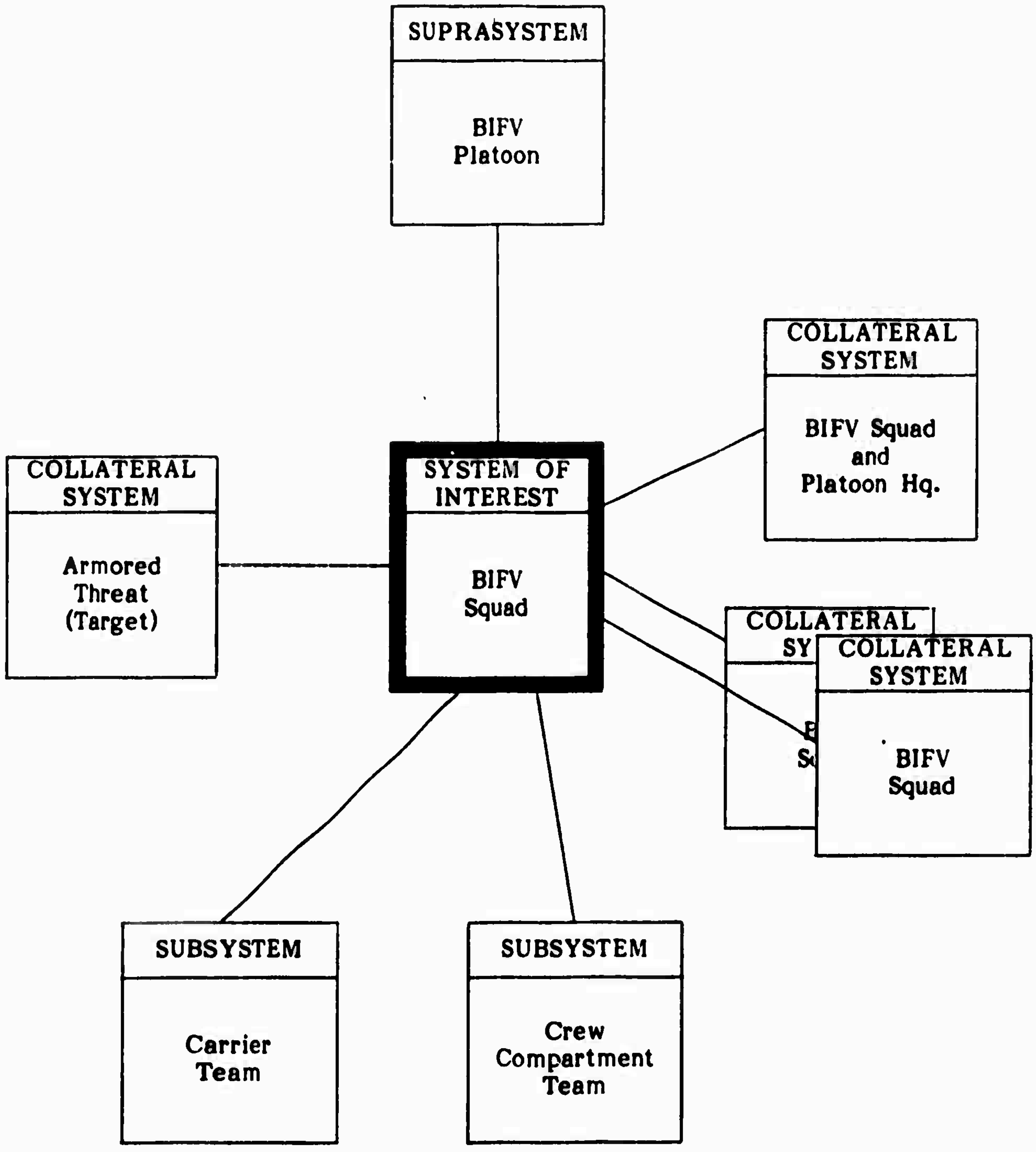


Figure 8. Example of a System Hierarchical Structure

performance with a particular level of description. The guidelines are given in Figure 7. Each cell's guidelines begin with the opening phrases of a statement that sets the context for the particular cell, and that establishes the format for the member taxa or dimension of that cell. A list of questions follows, each of which is intended to establish an analytic perspective that will aid the identification of those member taxa. The questions are not intended to be mutually exclusive. Neither do they necessarily constitute all of the analytic perspectives that might help in the identification of the system's work requirements. Rather, they reflect conceptual and organizational points of view that evolved from early trial applications of the emerging STM/APM, and that proved helpful for identifying taxa in subsequent applications.

7. Guidelines for Deriving Measurable System Attributes

Application of the guidelines discussed above (Figure 7) allows an analyst to identify and organize a system's work requirements (Figure 1, Block 1). Those work requirements establish the context for system design and system evaluation. The designer examines the work requirements and asks, "How can I build the system so that it satisfies the work requirements?" The evaluator examines those same requirements and asks, "How can I test the system to determine whether it satisfies the work requirements?" The designer must translate the work requirements into concrete design decisions, i.e., consciously control the physical features of the system so that adequate provision is made for the system to work as it should. The evaluator must translate the work requirements into a concrete set of measures that can be applied to observable features of the system to determine whether the system can work as it should, is working as it should, or has worked as it should.

The translation of work requirements allows the designer and the evaluator to focus on the system's ATTRIBUTES (Figure 1, Block 2). An attribute is a concrete, observable feature of the system that bears directly on the work that the system can and does perform. To the designer, an attribute is something that can be controlled. By controlling the attributes, the designer controls what the system can do and how well it can do it. To the evaluator, an attribute is something that is measurable. By measuring the attributes, the evaluator arrives at a judgment or appraisal of the system's work.

Figure 8 illustrates the translation of work requirements into attributes. The requirements chosen for the example are a sequence of the performance processes required of the Design (or Curriculum Development) subsystem of the Bradley Infantry Fighting Vehicle Gunnery Training System. The selected sequence consists of one objectives-level performance process (Analysis of Tasks), together with one of its functional purposes, and one characteristic of that functional purpose.

In order to build the system to carry out the "Analysis of Tasks" requirement properly, the training system designer must choose some appropriate analytic methods; insure that those methods address the purposes of the analysis (e.g., classification of domains of learning) and the technical details required to achieve those purposes (e.g., identification of physical skill

LEVELS OF SYSTEM DESCRIPTION	ASPECTS OF SYSTEM PERFORMANCE: PERFORMANCE POTENTIALITIES	PERFORMANCE PROCESSES	PERFORMANCE PRODUCTS	PERFORMANCE ENVIRONMENT	PERFORMANCE CONSTRAINTS
OBJECTIVES	"The System must be capable of ..." What must this system be capable of doing or providing? What prerequisite abilities, knowledge and skills must be incorporated into the system? What kinds of resources must the system possess? What needs is this system supposed to fulfill? What specific types of expertise must be built into the system? What kinds of techniques must the system be able to apply?	"The System must carry out the following activities ..." What jobs are required of this system? What procedures are involved in the mission that this system is to perform? What assignments does this system receive to support higher command? What methods will this system employ? What are the system's tasks? How is the system supposed to cause its intended effects?	"The System must produce ..." What products must the system deliver in the course of carrying out its mission? What goods or services must it output? What concrete results are being sought? What will the system supply to other, interacting systems? What changes is the system supposed to bring about? What are the system's intended effects?	"The System must operate under the following conditions ..." What naturally occurring factors may affect the system's work? What elements of the environment might affect the system's potentialities, processes or products?	"The System must operate under the following restrictions ..." What arbitrary limitations have been imposed upon the system's design or operation? What factors affecting the system's work have been imposed by doctrine or other intervention? What constraining elements might affect the system's potentialities, processes or products?
FUNCTIONAL PURPOSES	For each capability listed in the cell above: "This particular capability must allow the System to be able to ..." What are the purposes to which this potentiality might be applied? Why does the system need to have the particular prerequisite ability, knowledge or skill? Why is the particular expertise considered necessary? How is the system supposed to use this capability? What applications exist for this technique in this system? If the system did not have this particular ability, what needs would suffer?	For each activity listed in the cell above: "The reasons for carrying out this particular activity are to ..." What are the purposes for performing this particular job? What additional activities will the job enable the system to perform? What are the reasons for implementing this procedure? What will the system be required to accomplish in the course of this task? Why has the system been given this assignment? What will be learned as a result of this task? What will be accomplished as a result of this task?	For each product listed in the cell above. "This particular product will be used to ..." What benefits can be derived from this particular output? What use will the receiving system make of this product? What problem or need will this good or service solve? What further achievements will the product allow the system to pursue? If this product is not delivered, what problems will arise?	"The System's purposes must be satisfied in the face of ..." What environmental factors might affect the system's ability to apply its potentialities in the intended fashion? What environmental factors might affect the accomplishments that the system will achieve in carrying out its processes? What environmental factors might affect the ability to use the system's products in the intended manner?	"The System's purposes must be satisfied in the face of ..." What imposed restrictions might affect the system's ability to apply its potentialities in the intended fashion? What imposed restrictions might affect the accomplishments that the system will achieve in carrying out its processes? What imposed restrictions might affect the ability to use the system's products in the intended manner?
CHARACTERISTICS	For each application listed in the cell above "To apply the capability to this particular purpose, the system must be able to ..." What specific abilities are needed for that particular application? What different capabilities can be brought to bear on this purpose? What are the ingredients of knowledge, skill and ability that this purpose demands? What specific areas of experience are relevant to this application? What are the components of the techniques required to address this purpose?	For each purpose listed in the cell above "The tasks required to satisfy this particular purpose are ..." What steps must the system take to accomplish the purpose? What constituent operations are required to apply the process to this particular purpose? In what different ways can the system achieve this particular accomplishment? What task responsibilities will be assigned to individual personnel and equipment in support of this particular purpose? What decisions have to be formulated in pursuit of this purpose? What information processing must be undertaken in pursuit of this purpose?	For each application listed in the cell above "To serve that application, the system must deliver ..." What milestones must be achieved if the output is to be useful for this particular application? What intermediate goods and services are needed to assemble a useful finished product? What are the individual deliverable items that are essential to accomplish this particular intended purpose? What individual services must be provided to the receiving system to serve this purpose? What does the product have to include to be useful for this application?	"The System's performance characteristics may be affected by ..." What environmental factors might affect the system's constituent capabilities and prerequisites for performance? What environmental factors might affect performance of the system's constituent tasks? What environmental factors might affect the characteristics of the products delivered by the system?	"The System's performance characteristics may be affected by ..." What imposed restrictions might affect the system's constituent capabilities and prerequisites for performance? What imposed restrictions might affect performance of the system's constituent tasks? What imposed restrictions might affect the characteristics of the products delivered by the system?

Figure 7. Guidelines for Identifying Dimensions/Taxa of System Performance

WORK REQUIREMENTS	ATTRIBUTES
OBJECTIVES-LEVEL PROCESS:	
2.3 The System must carry out an analysis of the tasks selected for training.	• Task analytic methods applied to the BIFV Gunnery Tasks • Analytic factors assessed for the tasks • Completeness of the task analysis • Accuracy of the task analyses
Functional Purposes of that Process:	
2.3.1	
2.3.2 One purpose for the task analysis is to classify the tasks in terms of their domains of learning.	• Classification methods employed to identify domains of learning for BIFV Gunnery Tasks • The domains identified for each BIFV Gunnery Task
2.3.3	
Characteristics of that Functional Purpose:	
2.3.2.1	
2.3.2.2	
2.3.2.3 To Classify tasks in terms of domain, it is necessary to identify the physical skills to be acquired.	• Methods used to identify the physical skills required to perform BIFV Gunnery Tasks • The physical skill requirements identified for each task.
2.3.2.4	

Figure 8. Sample Set of Attributes Associated with System Work Requirements

requirements); insure that that the analysis considers all factors pertinent to the tasks; insure that the analysis extends completely to all of the tasks selected for training; maintain quality control over the analysis to insure that it is performed accurately; and, ultimately, see to it that the analytic results are produced when needed, and fully document all necessary items (e.g., domain classifications, skill requirements, etc.). These attributes are the features of the system that the designer must control (Figure 1, Block 3) to see to it that the task analysis work requirement is satisfied.

As seen in the APM Overview, these are also the very same attributes that the training system evaluator must measure to judge whether that task analysis work requirement is satisfied (Figure 1, Block 4). To appraise the system's task analytic work, the evaluator must consider whether appropriate analytic methods were selected; whether they were applied to serve the intended purposes, and whether they were applied in manners suited to those purposes; whether all pertinent factors were considered in the analysis, and whether any extraneous factors were included; whether all tasks selected for training were analyzed, and whether any extraneous or superfluous tasks were analyzed; whether the analyses were conducted accurately; and whether the intended analytic findings were produced.

8. Design and Evaluation as an Interactive Process

The designer's first step is to develop a preliminary plan for securing the identified system attributes. The plan addresses the products to be delivered and the processes to be implemented, but its principal focus is on the system's required potentialities. The designer's main task at this stage is to demonstrate that the system will have the prerequisite abilities needed to carry out the processes and deliver the products.

In parallel, the evaluator examines those same system attributes and develops a plan for testing whether the system has the attributes and satisfies the work requirements. The test plan includes measures and measure application procedures for all attributes. However, at this stage the evaluator principally is interested in selecting and applying measures of potential performance. This is the proposal stage of design and evaluation. The designer says, "Here is how I intend to see to it that the system will have the attributes it needs to work properly." The evaluator responds, "Here are the specific performance defects that I have found in your plan." The evaluator and designer work together to determine how the plan should be modified to correct the defects.

Now the designer implements the (modified) plan. The focus shifts from potential ("on paper") performance to in-process performance, as the specified activities are carried out. The evaluator again applies the measures to appraise the work, but now interest centers on the measures of process attributes. The kinds of questions that arise may include: Are the right kinds of activities being conducted? Is the plan being followed? Are we on schedule? Are procedures being adapted properly to meet the needs emerging in the real world of system development? The evaluator monitors the designer's work, and from time to time may report, "What you are doing there

isn't quite what is needed." In a cooperative effort, the designer and evaluator modify the on-going system processes to correct the defects uncovered.

At some point, the system is assembled and begins to deliver its products (Figure 1, Block 7). Again the evaluator applies the measures. The accent now is on whether the output goods and services satisfy the system's product requirements. If defects are noted, the measures of product, process, and potentiality help to diagnose their causes. It may be that all that is needed is to repeat the processes more carefully, i.e., to re-produce the products with greater attention to quality control. However, the evaluation might disclose that it is the processes themselves, or even their prerequisite potentialities, that must be reconstructed. An evaluation that interacts cooperatively with the design effort and that addresses all aspects of performance will be much more likely to help develop a well working operational system than will the old-fashioned "bottom line only" approach that traditionally is antagonistic to design.

Design and evaluation do not end with the "christening" of the operational system (Figure 1, Block 8). They remain living functions as long as the system continues to operate, always looking for possible improvements that will allow the system to respond to changing needs and/or to adopt newer, better technology and procedures.

9. Data Bases of System Performance Taxa: Focus on Training Applications

Extensive practical application of the APM requires the availability of taxonomies of system performance. Each such taxonomy is an organized data base. Its contents are the work requirements of the particular system, or family of systems, for which the taxonomy was prepared. A design or measurement analyst may examine the total data base and identify the specific performance elements relevant to the application at hand. As more taxonomies are developed, the scope of applications available to the model will increase.

To provide one such data base, generic taxonomies were developed for major functional subsystems of training systems. The decision to focus APM development on training applications reflects the observations that training systems are pervasive, critical to modern military operations involving sophisticated equipment, and consistent with ARI's primary interest in human behavioral issues.

Development of training system data bases for APM applications necessitated identification of the training system hierarchical structure, and subsequent generation of performance taxonomies for the members of that structure. It is functional, not organizational, structure that is of interest here. The organizations of two particular training systems may differ widely, but each will accomplish the same basic functions required of any training enterprise.

The principal generic function of training systems is postulated to be learning, defined as any activity involving the senses that affects behavior in some purposeful fashion. Learning is a human function: it is people who

carry out the sensory activities to experience the intended behavioral effects. The principal generic operator/staff member of a training system, thus, is the learner.

The other major generic function of training is postulated to be helping to learn, defined as providing an efficient learning environment to the learner. Numerous types of people, using a variety of equipment, may work in any given training system to make it conducive for the learner to learn. All such people are learning helpers. They acquire more specific titles in accordance with the particular types of help they provide.

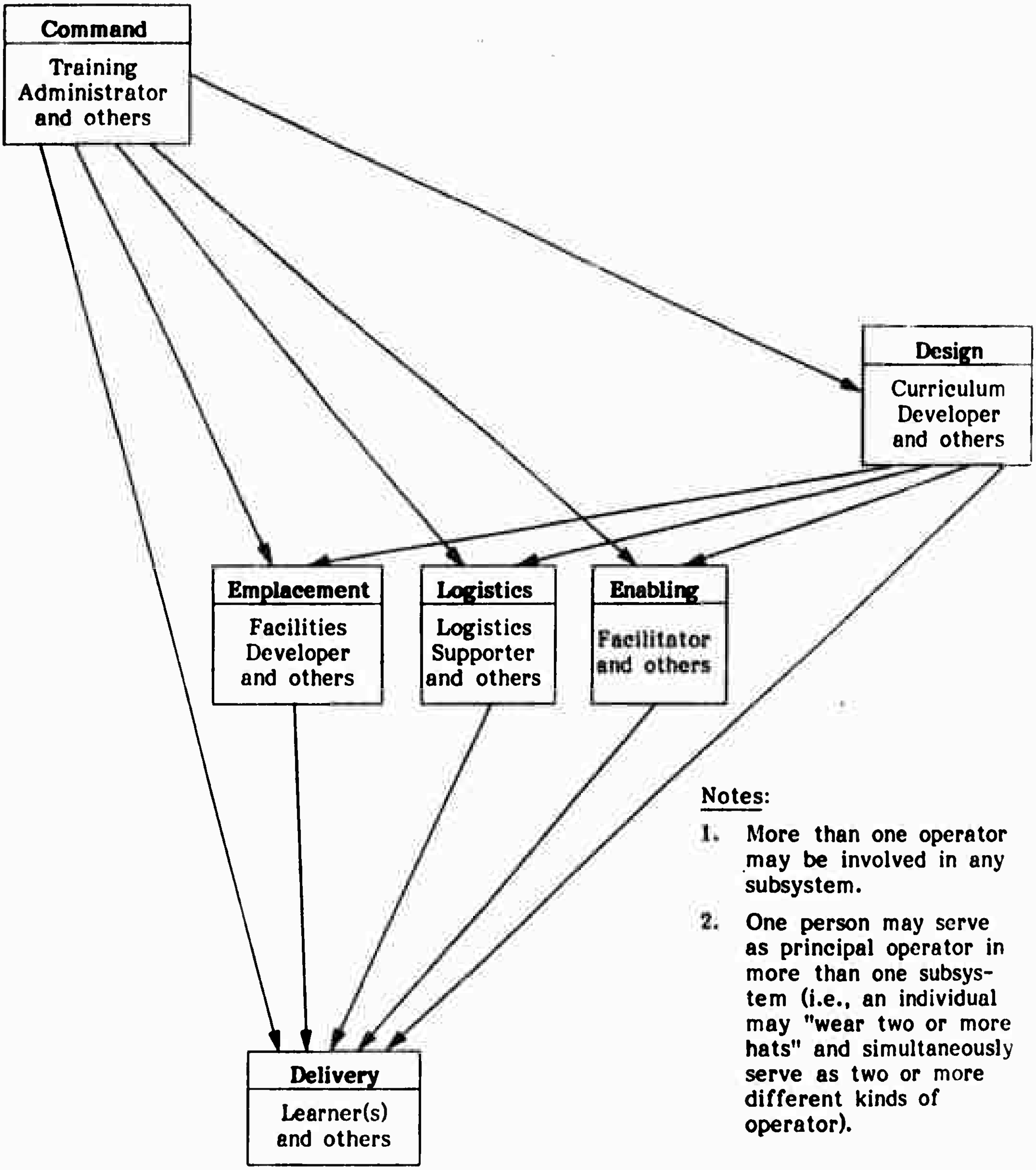
The two major functions can be broken down into more detailed operations, or subfunctions. These can be grouped conveniently into six generic training subsystems, as illustrated in Figure 9.

a. The administrative control, or Command Subsystem--which deals with identifying needs for training, allocating resources, recruiting training personnel, monitoring and evaluating learner performance, etc. Command Subsystem is staffed principally by training administrators. They help the learner to learn by constructing and managing the system in which the learning activities can take place.

b. The curriculum development, or Design Subsystem--which is responsible for planning the instructional activities, selecting training technology, assembling content material, defining instructor and student requirements, etc. The Design Subsystem is the portion of the training system in which the Instructional Systems Development (ISD) model is applied. Design Subsystem is staffed primarily by curriculum developers. They help the learner to learn by determining the specific behavioral effects that are needed and by planning the sensory activities that will lead to those effects.

c. The facilities development, or Emplacement Subsystem--which constructs or acquires and assembles all facilities and equipment needed to support the sensory learning activities. The Emplacement Subsystem takes the plans developed by the Design Subsystem and insures that all materials, equipment, installations, supplies, etc., needed to carry out those plans are made available. Emplacement Subsystem is operated mainly by facilities developers. They help the learner to learn by providing the tools needed to carry out the learning activities.

d. The logistics support, or Logistics Subsystem--which deals with maintenance of facilities and equipment, housing, feeding and recreation of training system personnel, replenishment of consumables, transportation of people and supplies, etc. The logistics supporters help the learner to learn by attending to the myriad of details necessary to keep the training system running smoothly and free of discomfort and distraction.



Notes:

1. More than one operator may be involved in any subsystem.
2. One person may serve as principal operator in more than one subsystem (i.e., an individual may "wear two or more hats" and simultaneously serve as two or more different kinds of operator).

Figure 9. Training Subsystems and Their Operators

e. The instructor preparation, or Enabling Subsystem--which deals with familiarizing instructors with the plans, content, equipment and facilities involved in the intended learning and with preparing the instructors to teach the course effectively. The Enabling Subsystem also is responsible for tailoring the general plans and material to the specific learning needs of a particular class or team of learners. The principal staff of the Enabling Subsystem are the instructors, teachers, professors, etc., who directly assist the learner in carrying out the prescribed sensory activities. Collectively, these people are called facilitators. They help the learner to learn by presenting information, demonstrating techniques, coaching the learner's efforts, evaluating and correcting performance, etc.

f. The instructional implementation, or Delivery Subsystem--which is where the learning/training actually takes place. In the Delivery Subsystem, the prescribed sensory activities are carried out, and the learner experiences the intended behavioral effects. The principal staff member of the Delivery Subsystem is the learner, aided by all of the other staff members identified above.

Figure 10 presents "what" performance is required of each subsystem, i.e., their generic objectives-level taxa of potentialities, processes and products. Those taxonomies were compiled by applying the objectives-level guidelines presented previously in Figure 7. No attempt was made to identify generic taxa of environment or constraints, since the scope of work did not allow for such development.

The functional purposes-level guidelines and characteristics-level guidelines of Figure 7 were applied to develop complete taxonomies for the Design, Enabling and Delivery Subsystems. Those are presented, respectively, in Appendices A, B and C. Those taxonomies provide a general data base for addressing virtually any design or evaluation issue concerning those three subsystems in virtually any training system.

10. Sample Derivation of Attributes for a Training System

An attribute previously was defined as a concrete, observable feature of a system that bears directly on the work that the system can perform. For each taxon of performance required of a system, there exist certain system attributes that determine whether and how well the system can satisfy that taxon. The designer controls those attributes to make the system work well. The evaluator examines those attributes to assess how well the system works.

To aid in identifying the system attributes associated with a given performance taxon, the analyst can "decompose" the system into its constituent parts. The "parts" of a human-machine system are the people who operate the system, the equipment/materials employed in the operation, and the procedures/methods by which the people employ the equipment and interact with each other. The derivation of attributes then proceeds as follows:

Subsystem	Potentialities	Processes	Products
Command	• Providing overall system management • Determining learning needs • Determining overall scope of effort • Providing financial resources • Insuring availability of qualified staff and tools • Maintaining quality control	• 'Market analysis' of learning demand • Analysis of resource requirements to meet demand • Cost-benefit assessment of potential training • Recruitment, screening, and selection of personnel • Screening and selection of equipment • Review and evaluation of performance	• System personnel • System materiel • Funds • Work assignments • Performance milestones • Performance assessments
Design	• Identifying goals and priorities • Establishing performance objectives • Analyzing the objectives • Defining training content • Defining training procedures • Evaluating the curriculum	• Job analysis • Assessment of tasks for training development selection • Analysis of selected tasks • Assessment of instructional requirements • Analysis of existing instruction • Instruction assembly • Conduct of training trials	• Documented job analysis • Stated performance objectives • Lesson plans • Training documents • Tests • Training trial data
Enabling	• Providing day-to-day training management resources • Insuring availability of instructional delivery expertise • Insuring availability of learning guidance expertise • Insuring availability of subject matter expertise • Familiarizing facilitators with the curriculum • Tailoring the curriculum to specific delivery applications	• Analysis of facilitator's ability to perform the tasks • Analysis of facilitator's ability to manage/implement the learning activities • Design activities to correct facilitator's deficiencies • Design activities to allow adaptation of the curriculum • Conduct of the facilitator's learning activities	• Qualified facilitators for given delivery applications • Curricula tailored to given delivery applications
Emplacement	• Insuring availability of adequate learning facilities • Insuring availability of adequate learning materials • Insuring availability of adequate instructional aids	• Analysis of curriculum to determine emplacement requirements • Acquisition, construction and/or modification of learning facilities • Acquisition, construction and/or modification of learning material • Acquisition, construction and/or modification of instructional aids	• Appropriate learning facilities for given delivery applications • Appropriate learning materials for given delivery applications • Appropriate instructional aids for given delivery applications
Logistics	• Insuring availability of adequate personnel support • Insuring availability of adequate facilities maintenance • Insuring availability of adequate equipment maintenance	• Analysis of delivery plans to determine logistics requirements • Development of schedule of personnel support services • Development of schedule of preventive maintenance services • Development of procedures for restorative maintenance • Acquisition of facilities and materials needed for delivery of the services • Deliverance of the services	• Personnel support services • Facilities maintenance services • Equipment maintenance services
Delivery	• Providing learners with the learning environment • Insuring learners' interaction with the environment • Managing learners' progress • Evaluating learners' achievement • Providing bases for system evaluation	• Analysis of specific learner's needs • Conduct preparation learning activities • Conduct presentation/demonstration learning activities • Conduct application/practice • Conduct learner testing • Acquisition of formative evaluation data	• Appropriate learning activities • Learners who have achieved the stated objectives • Assessment of learners' achievements • Formative evaluation data

Figure 10. Objectives-Level Performance Taxa of Training Subsystems

a. Determine which of the system's "parts" are involved in the performance taxon of interest.

Identify the specific operators or classes of operators who are responsible for the particular potentiality, process or product and/or who are included in that potentiality, process or product. Similarly, identify the specific equipment or materials used in or contained in that potentiality, process or product. Finally, determine which of the procedures/methods by which the operators employ the equipment pertain to that potentiality, process or product.

b. Identify the qualitative and quantitative traits or properties that the involved people, equipment and procedures must have in order to achieve or satisfy the performance taxon of interest.

The requisite traits might include specific aptitudes, expertise, strengths, reliability, fidelity, etc. These traits need not be directly observable. However, they must be directly relevant to the particular system potentiality, process or product being studied. And, if one of these traits is <u>not</u> observable, it must at least be possible to <u>infer</u> whether or <u>not</u> the trait is present.

c. Identify concrete, observable features of the involved people, equipment and procedures that provide bases for inferring reliably whether the essential qualitative and quantitative traits are present.

These concrete, observable features are the attributes of interest. That is, they are the controllable and measurable entities that determine the system's achievement of the performance taxon of interest.

To illustrate this process, consider Training Design Subsystem performance taxon 1.2, "Establishing Performance Objectives," (see Appendix A). Performance objectives can be defined as written, explicit descriptions of specific terminal behaviors that learners are required to demonstrate to signify successful training. Each performance objective states something specific that the learner will be able to do upon completion of training. (See the Glossary for a more complete definition of "Performance Objective.") Clearly, the potential for establishing performance objectives accurately and completely is an essential ingredient of the subsystem responsible for developing the training curriculum.

What "parts" of the Training Design Subsystem are involved in the potentiality of "Establishing Performance Objectives"? First and foremost, specific <u>people</u> are involved: the subsystem must designate key instructional system designer(s) having the ability to establish accurate, complete performance objectives. Secondly, important <u>materials</u> are involved: these materials consist of information or data that disclose what it is that the learners need to be able to do, on the job, following the end of their training. Lastly, instructional design <u>methods</u> are involved: the methods of interest are

the procedures that the instructional system designer(s) will use to collect and analyze the relevant data, and to translate the analytic findings into statements of performance objectives. In order to demonstrate that their training system has the potential for "Establishing Performance Objectives," the training designers must:

- Name and/or describe the individuals who will establish the objectives;
- Define the information to be collected and analyzed to establish the objectives;
- Define precisely how the information will be collected and analyzed.

What are the essential qualitative and quantitative traits that these people, materials and methods must have in order to insure the potentiality of "Establishing Performance Objectives"?

Certainly, the people designated for this task must possess expertise in the establishment of performance objectives, and they must be prepared to devote sufficient level of effort to that task for this particular training design project. The information to be used as the basis for establishing the objectives must be appropriate for that task, and it must be accessible to the training designers. The methods to be used to collect and analyze the information likewise must be appropriate, and adequate resource support for implementing those methods must be provided. In naming their staff and in defining the information and methods that will be used, the training designers must provide concrete evidence that these essential traits will be present.

What is the concrete evidence that the traits needed for "Establishing Performance Objectives" are present? That is, what are the system attributes that can be directly observed and examined to determine whether the training system satisfies that particular taxon?

Figure 11 lists concrete, observable features of training system people, materials and methods from which reliable inferences concerning the system's potential for "Establishing Performance Objectives" could be drawn.

11. Guidelines for Developing Measures Specifications

A measure is a judgment or appraisal about the thing-being-evaluated. Thus, a measure of a human-machine system attribute is an appraisal of the "goodness" of that attribute. Each measure supplies a particular quantum of evidence or insight about the degree to which the system possesses some feature that it needs to perform some element of its work. The guidelines for systematizing the specification of measures derive from a number of conceptual bases, or postulates.

- A system attribute is a variable across the population of human-machine systems that are supposed to possess the attribute.

Taxon: Establishing Performance Objectives

	Essential Traits	Concrete Attributes
People	• Expertise in the establishment of performance objectives • Sufficient level of effort for the assigned task	- specific efforts to be undertaken by each person - specific prior experience in the establishment of performance objectives for other training applications - education and training relevant to the establishment of performance objectives - samples of prior work in this area - endorsements of people for whom this type of work previously was done - time scheduled to be devoted to the establishment of performance objectives - remuneration to be received for that task
Equipment/Material	• Information to be obtained must be appropriate • Information to be obtained must be accessible	- the information specified for collection - source(s) from which the information is to be acquired - volume of data to be obtained - descriptions of applications of these types of data in previous, similar work - agreement/permission received from the source(s) to access the data - specific proof of the accuracy, completeness and representativeness of the data in the source(s)
Methods	• Data collection and analysis procedures must be appropriate • Sufficient resources must be provided to implement the resources	- prior success in applying the collection/ analysis procedures - compatibility of the procedures with the characteristics of the data to be collected - sequence and timing of procedural steps - compatibility of the procedures with the specific efforts to be undertaken by each staff member - cost of implementing the procedures - funds provided for implementing the procedures - supportive equipment/materials needed to implement the procedures - availability status of the supportive equipment/materials

Figure 11. Sample Attributes Associated with a Taxon of **Training Design Subsystem** Performance

- The value that the attribute takes on, in any given system, is a function of the degree to which the system possesses the attribute.

- The attribute's value may be a function of the values of simpler, constituent features termed the dimensions of the attribute. For example, if "area" is a relevant attribute of a rectangle, the value of that attribute can be expressed as a function (product) of the rectangle's base and height values.

- In some cases, it may be possible to estimate the value of an attribute directly. In other cases, it may be possible to estimate the values of the attribute's dimensions, and then to compute the attribute value.

- Different kinds of estimates of an attribute's value may be made. One kind is an estimate of absolute, or "true" value (e.g., obtained by using a yardstick to determine a man's height). A second kind of estimation deals with relative values of an attribute (e.g., identifying the man who is tallest, 2nd tallest, 3rd tallest, etc.). Still a third kind of estimate produces threshold-referenced attribute values (e.g., a rod of unknown absolute length could be used to partition the group of men into two classes, one class taller and the other shorter than the rod).

- A measure of an attribute is the estimate of the attribute's value. Thus, a measure may be direct or computed/derived, may be absolute, relative, or threshold-referenced, and also may come from nominal, ordinal or ratio scales.

- Numerous possible measures exist for any given attribute. The evaluator's principal challenge is to select measures that provide the kinds of estimates of attribute values that are appropriate to the measurement purpose at hand, and that permit those estimates to be made accurately, reliably, and efficiently.

- The attribute measures, when properly combined, will supply appraisal of the more general traits with which the attributes are associated (see Section 10.b., above). Similarly, the trait measures, in combination, provide the judgment of the system's performance with respect to the particular taxon of interest.

- The taxon measurement requirements thus dictate the kinds of estimates that are needed for the traits. In turn, the trait estimation requirements dictate the kinds of attribute estimates that are needed.

Figure 12 summarizes these concepts. The figure represents a general hierarchy of measurement. At the top, to which all branches lead, is the desired measurement of system performance: that is a judgment or appraisal of the system's satisfaction of a particular performance taxon of interest.

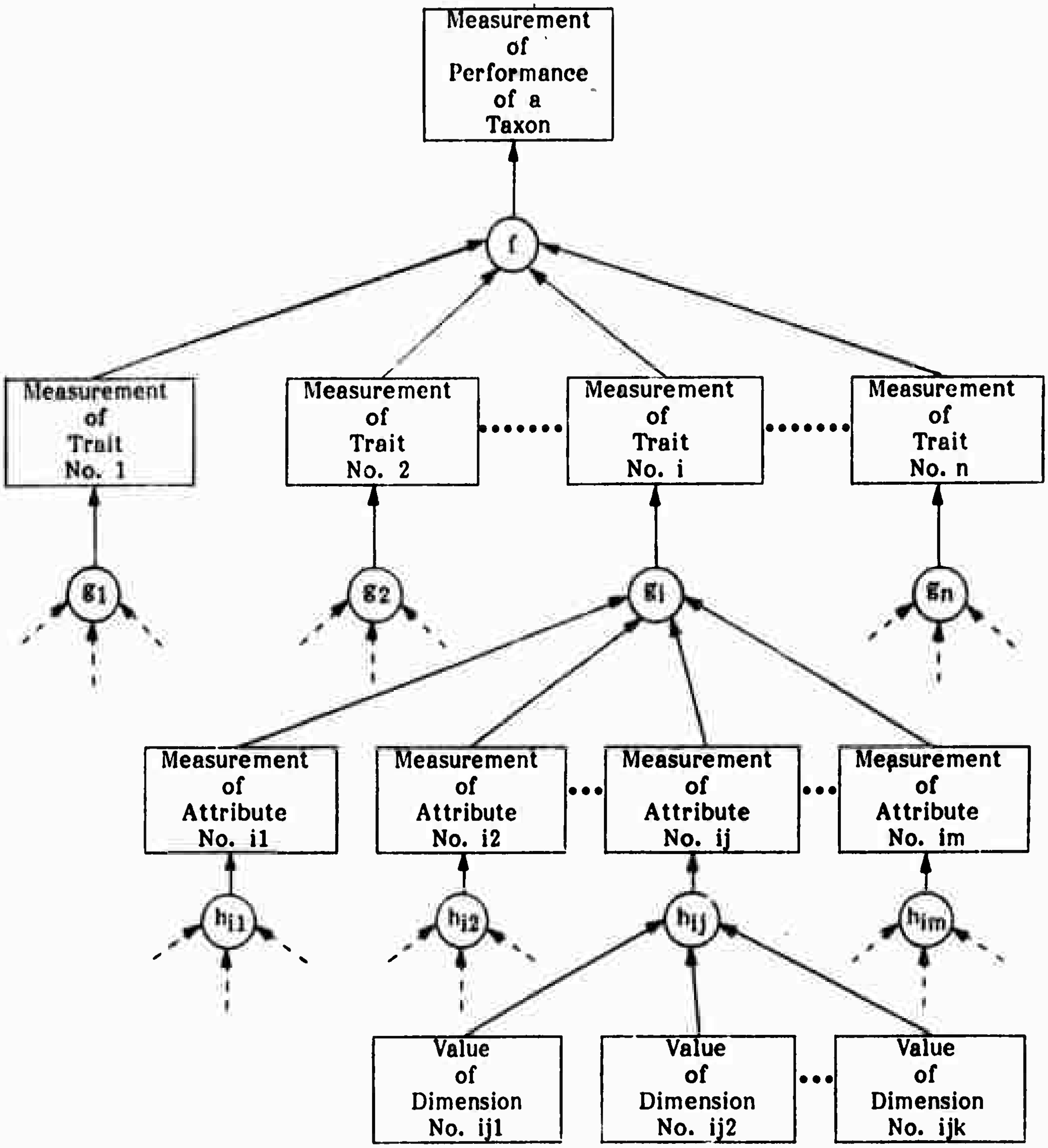


Figure 12. Schematic Representation of a General Hierarchy of Measurement

At the second level appear the traits or properties that the system must possess in order to satisfy the taxon. For the sake of generality, n of these appear in Figure 12. Each trait belongs to one of the three fundamental elements of a human-machine system: the people, the equipment, or the procedures. The measurement of system performance is a function, f, of the individual trait measurements. That is equivalent to saying that system performance is the sum total of the contributions of the system's people, equipment and their interactions. By measuring at the trait level, the evaluation process permits the respective contributions of these fundamental system elements to be appraised, and functionally combined to supply the judgment of system performance.

But any given trait may not be directly observable, and hence not directly measurable. Human traits in particular, but also equipment and procedural traits, may be abstract. However, if a trait is real, it must be possible at least to infer it from concrete, observable factors. Those factors are the attributes associated with the trait. The measurement of any given trait, e.g., trait No. i, is a function, gi, of the measurements of its individual attributes. Each trait has its own set of attributes, and its own functional relationship with its attributes.

Every attribute is concrete and observable. Thus, every attribute is at least theoretically directly measurable. But many attributes are complex, and difficult or expensive to measure directly. Often, those kinds of attributes are multi-dimensional, and thus their measurements may be computed from the values of simpler, unidimensional factors that are more amenable to direct measurement. That is, the measurement of a particular attribute, e.g., attribute No. ij, might best be obtained as a function, hij, of the values of its constituent dimensions. Each dimension is a factor amenable to practical direct measurement.

The links between given performance taxa and their related attribute dimensions may vary widely. Consequently, the intervening traits and attributes may be simpler (even identical from one level to the next) or more complex as well. Furthermore, the number of levels one chooses to analyze in the measurement hierarchy of Figure 12 may also be a function of what is feasible, how diagnostic one wishes to be and what is cost-effective.

The concepts discussed, exemplified and depicted above provide the basis for developing guidelines for selecting attribute measures, and for specifying how those measures are to be combined to supply a judgment of the system's performance relative to some taxon of interest. These guidelines proceed as follows:

a. Determine the kind of performance estimation that is required and appropriate for the particular taxon and measurement purpose at hand.

b. Determine the trait value estimates that are needed to support the required taxon measurement, and identify the functional relationship between the trait values and the taxon value.

c. For each trait, determine the attribute value estimates needed to support the trait measurement, and identify the functional relationship between those attribute values and the trait value.

d. Identify the dimensions of each attribute that may be used to generate the required value estimates.

e. Identify the functional relationship between the attribute value and the constituent dimension values.

f. Define the methods by which the dimension values will be obtained.

To illustrate the application of the measures specification guidelines, consider the following hypothetical situation:

> The U.S. Army Infantry School has issued a Request for Proposals (RFP) to undertake development of a training system to support introduction of a new squad automatic weapon. Responses have been received from several different organizations. A committee of training development experts has been assembled to review the proposals, and to select the organization best qualified to conduct the project. The committee has 6 members.

For simplicity, this illustration will address only the following Measurement Purpose:

> To review and evaluate a set of proposals received from training development organizations to identify the organization best suited to establish performance objectives for squad automatic weapon training.

The guidelines (a-f) are applied as follows:

a. Determine the kind of performance estimation required for this measurement purpose.

   A relative appraisal of the competing organizations' capabilities for establishing training objectives will suffice. The estimates should permit the organizations to be rank-ordered (e.g., "best qualified," "2nd best," ... etc.).

b. Determine the trait value estimates needed to support this performance measurement. Identify the functional relationship between the trait values and the performance measurement.

   The traits essential for satisfying the potentiality of establishing training objectives are (from Figure 10, earlier):

1) Expertise in establishing performance objectives
2) Adequate level of effort proposed
3) Appropriateness of information proposed for collection
4) Accessibility of the proposed information
5) Appropriateness of data collection/analysis procedures
6) Sufficiency of proposed resources

Every member of the review committee will review each proposal, and will make an independent judgment of each proposal with respect to the above-listed traits. Each trait will be assigned a value from 0 (insufficient) to 3 (excellent).

Thus, each reviewer will assign each proposal a value from 0 (totally insufficient on all traits) to 18 (excellent relative to all six traits). In turn, each proposal will receive a summary score from 0 (totally deficient in all respects to all reviewers) to 108 (excellent in all respects to all reviewers). Proposals will be rank-ordered in accordance with their respective summary scores.

c. For each trait, determine the attribute value estimates needed to support the trait measurement. Identify the functional relationship between the attribute values and the trait measurement. For example:

Trait No. 4: Accessibility of proposed information

Each offerer's proposal will be assessed relative to the following two attributes to arrive at a measurement of this trait:

1) Evidence that the offerer has secured or can secure permission to extract the proposed data from the proposed source(s).

2) Evidence that appropriate data of sufficient quantity and quality exist at the offerer's proposed source(s).

Each reviewer will make an independent assessment of these attributes for each proposal. Relative to attribute 1), the reviewer will assign a value from 0 (cannot be done) to 2 (can be done).

Relative to attribute 2), the reviewer will assign a value from 0 (not in existence) to 3 (exists in high quality and quantity).

After the reviewer has assessed a proposal relative to attributes 1) and 2), he/she will compute the measurement of Trait No. 4 using the table set forth below.

		Value of attribute 2)			
		0	1	2	3
Value of attribute 1)	0	0	0	0	0
	1	0	0	1	2
	2	0	1	2	3

Table entries are values for the "Accessibility of Proposed Information" (Trait No. 4). Other traits are determined using similar procedures defined by the analyst.

d. For each attribute, identify the dimensions that may be used to generate the required value estimates. For example:

Attributes associated with Trait No. 4: Accessibility of proposed information

1) Dimensions of the attribute: "Evidence that offerer has secured or can secure permission to extract the proposed data from the proposed source(s)."

Each reviewer will consider the following dimensions in assessing the evidence of the offerer's ability to access the proposed source(s):

a) The explicit documentation, in the offerer's proposal, that access to the proposed source(s) has been granted to this offerer for this project by authoritative representative(s) of the source(s).

b) Documentation, in the offerer's proposal, of his/her prior success in accessing similar information, for other projects, from the same proposed source(s).

c) Documentation, in the offerer's proposal, of his/her prior success in accessing similar information from source(s) similar to those proposed.

d) Potential impediments to access of the proposed source(s) that the offerer has identified in his/her proposal, but has not adequately addressed.

e) Potential impediments to access of the proposed source(s) known to the reviewer but not identified or addressed in the offerer's proposal.

<u>N.B.</u> The reviewer shall immediately inform the chairman of the review committee of any such impediments.

f) Reviewer's knowledge of the prior history of the proposed source(s) in granting/refusing access to this or similar offerer.

N.B. The reviewer shall immediately convey any such knowledge to the chairman.

The reviewer will consider no dimension or factor other than the six listed above when appraising this attribute, unless directed to do so by the review committee chairman.

2) Dimensions of the attribute: "Evidence that appropriate data of sufficient quantity and quality exist at the offerer's proposed source(s)." (not included in this sample)

e. For each attribute, identify the functional relationship between the attribute value and the constituent dimension values. For example:

1) Attributes associated with Trait No. 4: Accessibility of proposed information

a) Functional computation of the value of the attribute "evidence that offerer has secured or can secure permission to extract the proposed data from the proposed source(s)."

The reviewer must assign this attribute a value of 2 (highest possible value) if:

- Explicit documentation is included in the offerer's proposal to establish that grant-of-access explicitly has been received from authoritative representative(s) of all proposed sources, or

- All of the proposed sources are known to grant access to all users similar to this offerer, for purposes similar to those intended in the proposed project.

The reviewer must assign this attribute a value of 0 if:

- Any key source (i.e., the only source proposed by this offerer for accessing certain essential data) is known to refuse access to all users similar to this offerer, for purposes similar to those intended in the proposed project, or

- Any key source is known to have refused access to this offerer in the past, for purposes similar to those proposed, and the offerer has not demonstrated a method for securing future access in his/her proposal.

In the absence of all of the four conditions listed above, the reviewer will exercise his or her own best judgment in assigning a value of 0, 1, or 2 to this attribute. The reviewer is to be prepared to explain the rationale for his or her judgment.

b) Functional computation of the value of the attribute "evidence that appropriate data of sufficient quantity and quality exist at the offerer's proposed source(s)."
(not included in this sample)

f. Define the methods by which the dimension values will be obtained.

The principal method by which reviewers will obtain values for the dimensions described under item d., above, will be through a careful and complete study of the offerer's proposal.

In addition, for certain dimensions, a reviewer may possess relevant prior information that might affect the values of those dimensions. When a reviewer believes that he or she possesses such information, that information should be conveyed to the review committee chairman as soon as possible. The chairman will decide whether the information is to be considered in assessing the value of a particular dimension. Upon so deciding, the information will be conveyed to other reviewers.

Occasionally, due to the availability of relevant prior information, the chairman may determine that a particular dimension must be assigned a particular value by all reviewers.

12. Initial Concepts for Developing Design Specifications

Although the project's scope did not allow for as much development in the APM's design specification application as for the performance measurement applications, a preliminary set of concepts has been prepared. They are summarized briefly in this section.

A design specification of a human-machine system is a description of exactly what the system design should include in order for the system to achieve all of its performance requirements. As with the APM's measures specification procedures, the notion of a systematic design specification process rests on a number of conceptual bases, or postulates:

- Design and measurement deal with precisely the same issues: namely, the concrete, observable attributes that make the system what it is and that cause it to work in the way that it does.

- The design specifier, like the evaluator, thus must know how the concrete, controllable attributes are linked to the taxa they serve. Specifically, the design specifier must know the functional relationship between a taxon and its essential traits, and the functional relationship between each of those traits and its constituent attributes. Only then can he/she identify the attribute design choices to make to effect the appropriate status of the taxon.

- The design specifier's choices determine the value that each attribute will have in the system being built. Those choices determine the system's trait values through the functional relationships that link the traits and the attributes. Similarly, the trait values determine the values of the performance taxa.

- The design specifier's intention is to make the set of choices that maximizes the values of the taxa. Often, but not always, that involves attempting to maximize the attribute values. In some cases, the best choice may be to arrange for certain attributes to take on sub-maximum values, because the resulting combination produces the best attainable trait value.

- In sum, in making choices the design specifier needs to know and to apply the functional relationships that link the system attributes to the traits, and also the functional relationships that link the traits to the taxa.

- The design specifier also needs to know how to assess the values of the attributes, traits and taxa, to insure that appropriate design choices are made. That is, the design specifier needs to know the measures.

The concepts described above provide the basis for defining an initial set of guidelines for developing design specifications. That effort is left for future projects.

B. Applications of the APM for Measurement

The APM concepts and guidelines for measurement applications are next illustrated with more realistic examples. These illustrations summarize more complete descriptions to be found in the earlier project reports (Bloom, et al., 1981, 1982). Two narrowly focused measurement illustrations, related to the Bradley Infantry Fighting Vehicle (BIFV), are given: (1) Derivation of a BIFV Measures Hierarchy for the Surveillance Function, and (2) Derivation of Measurable Performance Objectives for the BIFV Training System.

1. Derivation of a BIFV Measures Hierarchy for the Surveillance Function

a. General Conditions

This example begins with a general look at many BIFV performance aspects, of which surveillance is only one. The application to surveillance is pursued after establishing that more general context. For the general case, the overall measurement purpose was taken to be:

- To evaluate the combat readiness of a BIFV squad serving as the gounding element of a platoon in bounding overwatch during an offensive maneuver within an armored threat environment.

This measurement purpose was chosen for several reasons:

- First, the BIFV weapons system is a complex system and any attempt to apply the APM to a unit size larger than a squad would require analyses beyond the scope of the present effort.

- Second, a mounted operation with the squad activity limited to conducting bounding overwatch maneuvers and an engagement with a stationary armored threat were selected primarily to keep the number of variables manageable.

- Third, it was intended that this application would serve as a useful experience in utilizing available system documentation and could adapt information/doctrine from similar type systems as would a military analyst in applying the methodology to a new system.

Certain assumptions made were with regard to the qualifications of the BIFV squad/platoon personnel and the BIFV Table of Organization and Equipment (TOE). These assumptions were as follows:

- The BIFV/Squad/Platoon personnel are MOS-qualified and have completed the necessary unit team training in order to participate in combat readiness exercises.

- The BIFV squad is manned by TOE-authorized levels. For the purpose of this application, the assumption was made that the BIFV squad consists of nine personnel, i.e., Track Commander, Gunner, Driver and six (6) Firing Port Operators, one of whom is a fire team leader.

- The BIFV is prepared for this mission with maximum authorized TOE supplies and equipment.

- The BIFV squad will remain mounted during the entire tactical operation and would only dismount personnel if absolutely necessary, e.g., prepare vehicle for fording, etc.

b. Determine the Hierarchical Structure in Which the System of Interest is Imbedded

Figure 6 (presented earlier) depicts the external view of the hierarchical structure providing the immediate context of the BIFV Squad. For this measurement purpose, the system of interest is imbedded in a subsystem/system/suprasystem structure that encompasses a BIFV Platoon. Within the system of interest there are two subsystems: (1) the Carrier Team Subsystem, consisting of the Track Commander, Gunner and Driver, with their associated work stations and equipment, and (2) the Crew Compartment Team Subsystem, consisting of the six Firing Port Weapons Operators and their associated work stations and equipment. The two subsystems could be further divided into sub-subsystems which would bring the level to individual system operators and their associated equipment. However, considering the measurement purpose, this level is beyond the application interest of the APM. The collateral systems include two (2) other BIFV squads, one (1) BIFV squad/platoon headquarters and the threat system(s). The suprasystem is the BIFV platoon.

In applying the APM, one should develop the total number of taxonomic sets to which the system of interest belongs, including sets for each subsystem and corresponding sets for the collateral systems and for the suprasystems. The development of taxonomies for the various system levels leads to the identification of system-level interactions which influence relevant performance requirements and, in turn, affect performance measurement issues for the system of interest.

c. Define and Review Scenarios and/or Documents Required for This Application

In order to become thoroughly familiar with the BIFV Squad/Platoon system, available system documents were reviewed. Those documents included the BIFV Materiel Needs document, BIFV Systems Specifications, Mission Scenarios, BIFV System Task Descriptions, and Field Manuals (for similar systems) that provided guidance with regard to tactical operations. As a point of departure and initial guidance with regard to the measurement purpose, use was made of the Mission Scenario #1 (Bounding Overwatch Operation) from the BIFV/CFV Personnel Selection Study (Bloom et al., 1979). The first page only of that scenario is reproduced here in Figure 13. A squad verbal order was also developed to serve as guidance, and to aid in the identification of system population categories relevant to the contextual stages of the measurement process. The verbal order is presented in Figure 14. Its associated map is not shown here.

Specifying the measurement purpose also requires description of the measurement conditions. These include such factors as the geographic area(s) in which the system is to perform its mission, the time period during

TIME Min:Sec.	EXTERNAL SOURCE	TRACK COMMANDER	GUNNER	DRIVER	SQUAD AREA CREW (No. 4-9 FPWO's)
		INITIAL CONDITIONS - Platoon located at hill 450. Approaching hill 452. Mission - secure hill 452. - We are bounding element of 4 vehicle (IFV) platoon. - Daylight, contact expected. - Hill 452 is 1500M NE of 450. - Radio silence until contact. - Popped hatch mode on all vehicles. - Platoon (-) in overwatch on hill 450. - Initial bound to be 300m. - Vehicle prepared for move, turret weapons "battle sight." - TC has assigned sectors of surveillance to crew and general route to Driver.			
0:00	Platoon Leader Hand Signal	Receive hand signal to initiate bound			
0:03		Order "Driver left, move out" Observe turret indicator lights Select stabilization "On" Observe stabilization "On" indication	Announce "placing turret in motion" (IC) Observe turret indicator lights	Maneuver vehicle - - Depress foot brake - Release hand brake - Set driving range selector to "Drive" - Observe route of desired heading	Announce "turret deck clear" (FTL via IC) Observe assigned areas through vision blocks; FPWs at ready position (crew)
0:08		Observe assigned sector Maintain air surveillance	Squeeze palm switch and turn control handles to left Observe assigned surveillance area. Note turret reaching left sector limit.	Announce "Moving Out" Release foot brake, depress throttle Maneuver vehicle to desired heading	(Continuous)

Figure 13. Mission Scenario (First page only for sample purposes)
Mission Segment: Offensive Operation: Squad is Bounding Element
Bounding Overwatch - Contact Expected

SITUATION

"We are going to conduct an attack at 0600 hours today. This terrain sketch I've made represents the ground we've got to cover. As you can see the attack will cover a distance of about 3 kilometers. These little hills, 549 and 546 are platoon intermediate objectives. Hill 553, west of Lahm is the platoon objective. We are presently on Hill 578. From what I was able to see from the limited recon with the platoon leader, it looks like the enemy has withdrawn to positions north of Lahm. Although I didn't see any armored vehicles, Lt.Davies said the enemy has been identified as part of a motorized rifle unit. That means we have to be on the lookout for BMPs and maybe some tanks. We may also encounter such obstacles as minefields and wide trenches. The minefields are more than likely going to be forward of the trenchlines."

"Throughout the attack we will stay mounted. The 1st Platoon will be on our left and the 3rd Platoon on our right. The platoon objective is going to be hit with artillery and mortar fire just before we go in. The company has tanks attached to support us through the attack.

MISSION

"Our mission is to attack each of these intermediate objectives and final objective. We have to clear the trenches and bunkers in our zone. Upon securing Hill 553 we are to prepare defensive positions. Once we're there and see the terrain we'll talk more about it. We will move out at 0600."

EXECUTION

"When we move out, the platoon is going to be using bounding overwatch and we are the bounding squad. With the platoon overwatching us from this hill, we will move up this draw until we get to the patch of woods. I couldn't see much of these woods; so once we get close I'll guide the track over the remainder of the route. As soon as the rest of the platoon moves up to us, we'll bound around to the left and up this ridge line. I could see it pretty clearly, and I don't think anything is up there. When the rest of the platoon has moved up and all the tracks are in position we'll wait for Lt. Davies' order to bound to the first intermediate objective, Hill 549. Once we've taken Hill 549 we'll wait for Lt. Davies' order to continue bounding overwatch. It's important that we don't get too far ahead or behind the rest of the company. If we detect a mine field we'll try to go around it so keep your eyes open."

"If we have to dismount, the platoon sergeant will be controlling the fires of the carrier team but that is very unlikely. Our priority is to engage any armored vehicles in our sector and then bunkers."

"When we get to the trenches and enemy contact is made, Sgt. Jones will control the fires of the FPWO's. Don't take any chances; lay down a good base of fire. Report all possible targets for the carrier team."

SERVICE SUPPORT

"Sgt. Jones, you make sure that the squad compartment and crew have the required basic load and equipment. Let me know when you're all complete. I'll check the carrier team supplies and equipment."

"McCarthy, the POL track will be here around 0430; make sure our fuel tank is topped off."

"Take care of any casualties within the track; give him some quick first aid and get back to your position. The company aid track will come forward just as soon as each intermediate and final objective is secured."

COMMAND AND SIGNAL

"We will cross the SP at 0600 on Lt Davies' hand signal. We will maintain radio silence until we reach Hill 549. During the attack no unnecessary intercom chatter."

"In case I get hit, Sgt. Kowalski, you take over; our call sign is TANGO 31."

"OK, the time is now 0230; I will inspect at 0515 hours. It will be daylight at 0545. We have less than 4 hours before we move out. We will maintain radio silence until contact with the enemy is made. The platoon and the squad will use arm and hand signals during the maneuvers. Remember to maintain light and noise discipline. Do you have any questions? If not, get ready."

Figure 14. Verbal Squad Order
Purpose: To Attack Hills 549, 546 and 553 (Lichtenfels, Deutschland)

which the system is to perform its mission, the weather conditions and any other limiting variables. As noted in the verbal squad order for this application, the geographic area selected is a temperate zone of operations in Southern Germany; the time period of performance is 0600 to 1200 hours; the weather is defined as fair, no precipitation, and good visibility.

d. Begin Applying the APM to the System of Interest to Derive Taxonomy Sets

The analyses of the two subsystems were initiated first, since it was felt that combining the subsystem taxonomies would simplify the derivation of the taxonomy for the system of interest itself. The initial subsystem selected for analysis was the Carrier Team. The APM revision was applied to Carrier Team and Crew Compartment Team subsystems, separately, to derive the fifteen different taxonomy subsets. These correspond to the "intersections" of each of the three levels of system description with each of the five contextual stages of the measurement process. Figure 5 (presented earlier) is a sample of that effort, and incorporates the decimal number indexing scheme described earlier.

At the Objectives Level, the population categories were assigned successive numbers in the first decimal position. For example, at the Objectives Level under Potentialities, each population category was identified as 1.1, 1.2, 1.3, etc. To be specific, the taxa identified on the Objectives Level system description for the Potentialities of the BIFV Carrier Team were designated as follows:

1.1 Providing surveillance
1.2 Conducting weapons fire
1.3 Providing squad command and control
1.4 Providing transportation
1.5 Providing communication
1.6 Providing squad protection

The Functional Purposes Level descriptions were assigned a two-decimal code, i.e., 1.1.1, 1.1.2, 1.1.3, etc. To continue the above example, the Functional Purposes Level taxa of "1.1 Providing surveillance" were designated as:

1.1.1 Conducting sector surveillance
1.1.2 Detecting targets
1.1.3 Acquiring targets
1.1.4 Identifying/classifying targets
1.1.5 Tracking targets

The Characteristics Level of Potentialities was assigned a three-decimal code, i.e., 1.1.1.1, 1.1.1.2, 1.1.1.3, etc. In subdividing the functional purpose "1.1.1 Conducting sector surveillance," the characteristics which describe what capabilities the system must have in order to satisfy that application were numbered as follows:

1.1.1.1 Unaided visual sector surveillance capability
1.1.1.2 Aided visual sector surveillance capbility
1.1.1.3 Infrared sensor sector surveillance capability

e. <u>Derivation of a BIFV Measures Hierarchy for the Surveillance Function</u>

As a test of the utility of the resulting BIFV taxonomy, a set of measures was derived from those taxa associated with the Carrier Team Unit's performance of surveillance. The advantages in choosing the performance element of surveillance were that, first, it is a requirement common to many military human-machine systems and, second, it entails many potentialities, processes, and products of performance and is subject to the influence of many environmental and constraining factors. Thus, as a test of the measures-derivation process, it permitted a wide variety of system taxa to be included and offered the possibility of producing measures relevant to many system applications.

Figure 15 displays the Carrier Team System taxa associated with the "surveillance" performance element. On the Objectives Level of system description, these taxa include:

- The basic capability (potentiality) of surveillance.
- The process of sector surveillance, for both air and ground sectors.
- The product of threat detections (for which surveillance is a prerequisite).
- The physical and climatological environment.
- Surveillance constraints.
- Threat constraints (the nature of the threats, and the tactical response required, may affect how the system performs surveillance).

All taxa that "descend" from these on the Functional Purposes Level and the Characteristics Level also are included.

The numbers shown in parentheses in Figure 15 refer to the taxonomy codification scheme illustrated earlier in Figure 5. They allow the links among the three levels of description to be indicated explicitly. For example, taxon 1.1.2.1 "descends" from taxon 1.1.2, which in turn "descends" from 1.1.

The taxa arrayed in Figure 15 could next be used as search terms for accessing the body of published literature on human-machine systems measurement, with a view toward identifying measures, analytic methods, and other test procedures that previously were applied successfully to evaluate similar systems. For purposes of this example, however, it was not deemed necessary to conduct a formal literature review. Instead, the staff members relied on their own system measurement experience with surveillance systems (especially those in the infantry and air defense artillery contexts) as the source from which measures relevant to the listed taxa would be drawn.

	POTENTIALITIES	PROCESSES	PRODUCTS	ENVIRONMENT	CONSTRAINTS
OBJECTIVES	Possess Capability: Surveillance (1.1) Capability	Perform Process: Air/Ground Sector (2.2) Surveillance Processes	Output Product: Threat (5.2) Detections	In the Presence of: Rolling Terrain (3.1) Rural/Agricultural (3.2) Indigenous Obstacles(3.3) Summer Fair (3.4) Weather	In Compliance with: Surveillance (4.1) Constraints Threat (4.5) Constraints
FUNCTIONAL PURPOSES	Apply Capability for: Surveying Sector (1.1.1) Detecting Targets (1.1.2) Acquiring Targets (1.1.3)	Apply Processes to: Locate Signatures (2.2.1) Locate Avenues (2.2.2) Locate Threats (2.2.3)	Apply Products to Provide: Enemy Locations (5.2.1) Intelligence Information (5.2.2) Tactical Decisions(5.2.3)	Performance Subject to: Hills, Valleys, Flat(3.1.1-3) Fields, Roads,(3.2.1-4) Farms, Forests, Stone Walls, Rocky Outcroppings, Marsh/Swamp (3.3.1-5) Trees, Trenches, Warm/Hot, Daylight, no precipitation, Good Visibility (3.4.1-4)	Performance Subject to: Continuous Surveillance (4.1.1) Likely Threat Observation (4.1.2) Appropriate Threat Neutralization (4.5.1)
CHARACTERISTICS	Accomplish Purpose with: Unaided Visual Surv.(1.1.1.1) Aided Visual Surv.(1.1.1.2) Visual Detection (1.1.2.1) IR Detection (1.1.2.2) Visual Viewing (1.1.3.1) IR Viewing (1.1.3.2) Visual Identifying (1.1.4.1) Tracking Moving TGT While Moving (1.1.5.1) Tracking Stationary TGT (1.1.5.2) Tracking Moving TGT While Stationary (1.1.5.3)	Accomplish Purposes with: Signature Detection (2.2.1.1) Signature Identification (2.2.1.2) Avenue Assessment (2.2.2.1) Avenue Classification (2.2.2.2) Threat Dection (2.2.3.1) Threat Identification (2.2.3.2) Threat Classification (2.2.3.3)	Accomplish Purposes with: Signature locations (5.2.1.1) Actual Threat Locations (5.2.1.2) What was Observed (5.2.2.1) How Many Observed (5.2.2.2) Where/When Observed (5.2.2.3) Actions by Enemy (5.2.2.4) Degree of Threat (5.2.3.1) System Capability (5.2.3.2) Threat to Mission (5.2.3.3)	Performance Subject to: All Characteristics of Environment Apply: Upslope: 250m, 8° Downslope: 1000m, 8° Flats: 1000m Fields: cultivated/ incultivated Roads: Secondary, light Duty, Trails Farms: Livestock, crops Forests: deciduous, coniferous, mixed Bypass Constraints for: walls, outcroppings, marshes, swamps, trees trenches Temperature: 27°-32°C Humidity: low-mod. Light: morning, sunny Climate: dry, dusty Visibility: clear, glare	Performance Subject to: Continuous Scan (4.1.1.3) Hatch Down (4.1.1.4) Train Surveillance (4.1.2.2) Minimum Exposure (4.5.1.2)

Figure 15. Carrier Team System Taxa Associated with "Surveillance" Performance Element

Figures 16, 17, and 18, respectfully, depict the measures that are potentiality-oriented, process-oriented, and product-oriented. The first set of measures (Figure 16) are intended to answer questions about the basic capabilities for surveillance that the system possessed. The second set (Figure 17) answers questions concerning how the system performs its various surveillance activities. The third set (Figure 18) addressed questions concerning the results of those surveillance activities.

Each set of measures is organized in conformance to the APM's three levels of system description. The uppermost row in each figure contains only those measures associated with Objectives Level taxa. The second row is reserved for measures associated with Functional Purposes Level taxa. All lower rows deal with measures associated with Characteristics Level taxa. Measures are labelled with reference to the particular attribute (taxon) of performance on which they bear. Each such taxon is itself designated by a numeric-decimal label. Each measure associated with a given taxon is labelled by that taxon's numeric-decimal, with parenthetic alphabetic postscript. For example, three measures are identified in Figure 16 for the "Surveying Sector" taxon designated by 1.1.1 (a Functional Purposes Level taxon under the Performance Potentialities column). Those three measures are designated by 1.1.1(A), 1.1.1(B), and 1.1.1(C), respectively.

One important point that bears re-emphasis is that all measures listed in Figures 16, 17 and 18 focus on the system's performance of surveillance. Each measure derives from some particular system taxon, but the measure is concerned only with the interaction of that taxon with surveillance. If some other aspects of system performance (e.g., "Squad Command and Control," "Communications") had been under study, the relevant taxa might have included some items that are similar to those listed for "surveillance." However, even if the taxa were identical for the several performance aspects, different measures would most likely have been derived because of differing measurement purposes.

Some examples can clarify the preceding point. One of the product-oriented taxa associated with surveillance is "Tactical Decisions" (Item 5.2.3, on the Functional Purposes Level in Figure 18). The association stems from the fact that surveillance is a principal source of input for BIFV Squad tactical decisions. If an analyst wishes to undertake a comprehensive assessment of the system's performance of surveillance, one issue that must be addressed, therefore, is "How well does the system's surveillance provide input to its tactical decisions?" It is precisely that issue that is addressed by the measures listed under "Tactical Decisions" in Figure 18. The reader will note that those measures have nothing directly to do with the kinds of tactical decisions made, with the correctness of those decisions, with the decision-making process itself. The measures are concerned only with the kinds and quantities of tactical decision input data supplied or overlooked by the surveillance process. Those measures are applied in the context of tactical decisions, but they remain focused on surveillance.

Suppose for the moment, however, that measures were being sought not for the "Surveillance" performance element, but rather for "Squad Command and Control." Tactical decisions would also be included in the set of

OBJECTIVES	**Surveillance Capability** 1.1(A) Types of surveillance methods/mechanisms included in the system 1.1(B) Environments that can be surveyed by the system				
FUNCTIONAL PURPOSES	**Surveying Sector** 1.1.1(A) Kinds of sectors that the system can survey 1.1.1(B) Sector physical limits 1.1.1(C) Sector scan rates	**Detecting Targets** 1.1.2(A) Kinds of targets the system can detect 1.1.2(B) Methods/mechanisms of detection 1.1.2(C) Detection probabilities (function of time, target) 1.1.2(D) False alarm probabilities 1.1.2(E) Receiver operating characteristics 1.1.2(F) Detection time lags	**Acquiring Targets** 1.1.3(A) Kinds of targets the system can acquire 1.1.3(B) Methods/mechanisms of acquisition 1.1.3(C) Acquisition probabilities/given detection (function of time, target) 1.1.3(D) Acquisition time lags	**Identifying Targets** 1.1.4(A) Kinds of targets the system can identify 1.1.4(B) Methods/mechanisms of identification 1.1.4(C) Probabilities of correct identification/given acquisition 1.1.4(D) Identification time lags	**Tracking Targets** 1.1.5(A) Kinds of targets the system can track 1.1.5(B) Methods/mechanisms of tracking 1.1.5(C) Tracking rates 1.1.4(D) Tracking accuracy
CHARACTERISTICS	**Unaided Visual Surveillance** 1.1.1.1(A) Physical parameters of field of view 1.1.1.1(B) Amount of sector that can be covered 1.1.1.1(C) Unaided visual scan rates **Aided Visual Surveillance** 1.1.1.2(A) Physical parameters of field of view 1.1.1.2(B) Amount of sector that can be covered 1.1.1.2(C) Degree of visual enhancement 1.1.1.2(D) Aided visual scan rates **IR Sensor Surveillance** 1.1.1.3(A) Physical parameters of IR sensor field 1.1.1.3(B) Amount of sector that can be covered 1.1.1.3(C) IR sensor scan rates 1.1.1.3(D) Minimum temperature differential thresholds	**Visual Detection Ability** 1.1.2.1(A) Visual detection probabilities 1.1.2.1(B) Visual false alarm probabilities **IR Detection Ability** 1.1.2.2(A) IR detection probabilities 1.1.2.2(B) IR false alarm probabilities	**Visual Acquisition Ability** 1.1.3.1(A) Visual acquisition probabilities **IR Acquisition Ability** 1.1.3.2(A) IR acquisition probabilities	**Visual Identification Ability** 1.1.4.1(A) Probabilities of correct visual identification **IR Identification Ability** 1.1.4.2(A) Probabilities of correct IR identification	**Ability to Track Moving Targets, While Moving** 1.1.5.1(A) Tracking stability (function of own speed) 1.1.5.1(B) Maximum angular velocity limits 1.1.5.1(C) Maximum angular acceleration limits **Ability to Track Stationary Targets, While Moving** 1.1.5.2(A) Tracking stability (function of own speed) 1.1.5.2(B) Maximum angular velocity limits 1.1.5.2(C) Maximum angular acceleration limits **Ability to Track Moving Targets, While Stationary** 1.1.5.3(A) Maximum angular velocity limits 1.1.5.3(B) Maximum angular acceleration limits

Figure 16. BIFV Surveillance: Potentiality-Oriented Measures

<table>
<tr><td>OBJECTIVES</td><td colspan="3">Air/Ground Sector Surveillance Processes
2.2(A) Kinds of surveillance processes included in the system
2.2(B) Procedures employed to implement the surveillance processes</td></tr>
<tr><td>FUNCTIONAL PURPOSES</td><td>Locate Signatures
2.2.1(A) Types of signatures to be located
2.2.1(B) Procedures used to locate signatures
2.2.1(C) Data acquired relevant to signature location
2.2.1(D) Data interpreted relevant to signature location</td><td>Locate Avenues
2.2.2(A) Types of avenues to be located
2.2.2(B) Procedures used to locate avenues
2.2.2(C) Data acquired relevant to avenue location
2.2.2(D) Data interpreted relevant to avenue location</td><td>Locate Threats
2.2.3(A) Types of threats to be located
2.2.3(B) Procedures used to locate threats
2.2.3(C) Data acquired relevant to threat location
2.2.3(D) Data interpreted relevant to threat location</td></tr>
<tr><td>CHARACTERISTICS</td><td>Signature Detection
2.2.1.1(A) Degree to which available signature detection data were actually acquired
2.2.1.1(B) Degree to which acquired data were correctly processed
2.2.1.1(C) Degree to which results were correctly interpreted

Signature Identification
2.2.1.2(A) Degree to which available signature identification data were actually acquired
2.2.1.2(B) Degree to which acquired data were correctly processed
2.2.1.2(C) Degree to which results were correctly interpreted</td><td>Avenue Assessment
2.2.2.1(A) Degree to which available data on likely threat avenues were actually acquired
2.2.2.1(B) Degree to which acquired data were correctly processed
2.2.2.1(C) Degree to which results were correctly interpreted

Avenue Classification
2.2.2.2(A) Degree to which available avenue classification data were actually acquired
2.2.2.2(B) Degree to which acquired data were correctly processed
2.2.2.2(C) Degree to which results were correctly interpreted</td><td>Threat Detection
2.2.3.1(A) Degree to which available detection data on threats were actually acquired
2.2.3.1(B) Degree to which acquired data were correctly processed
2.2.3.1(C) Degree to which results were correctly interpreted

Threat Identification
2.2.3.2(A) Degree to which available threat identification data were actually acquired
2.2.3.2(B) Degree to which acquired data were correctly processed
2.2.3.2(C) Degree to which results were correctly interpreted

Threat Classification
2.2.3.3(A) Degree to which available threat classification data were actually acquired
2.2.3.3(B) Degree to which acquired data were correctly processed
2.2.3.3(C) Degree to which results were correctly interpreted</td></tr>
</table>

Figure 17. BIFV Surveillance: Process-Oriented Measures

OBJECTIVES	**Threat Detections** 5.2(A) Kinds of threats detected by the system 5.2(B) Kinds of threats not detected by the system 5.2(C) Kinds of false detections produced by the system		
FUNCTIONAL PURPOSES	<u>Enemy Locations</u> 5.2.1(A) Kinds of enemy locations identified correctly 5.2.1(B) Kinds of enemy locations not identified 5.2.1(C) Kinds of false enemy locations mis-identified 5.2.1(D) Numbers of enemy locations identified (for each kind) 5.2.1(E) Numbers of enemy locations not identified (for each kind) 5.2.1(F) Numbers of false enemy locations mis-identified (for each kind)	<u>Intelligence Information</u> 5.2.2(A) Kinds of intelligence information correctly compiled (from observation) 5.2.2(B) Kinds of intelligence information incorrectly compiled 5.2.2(C) Kinds of available intelligence information not compiled 5.2.2(D) Numbers of correct intelligence reports compiled 5.2.2(E) Numbers of incorrect intelligence reports compiled 5.2.2(F) Numbers of available intelligence reports not compiled	<u>Tactical Decisions</u> 5.2.3(A) Kinds of information (relevant to tactical decisions) that were correctly gleaned from observation 5.2.3(B) Kinds of information (relevant to tactical decisions) that were incorrectly gleaned from observation 5.2.3(C) Kinds of available information (relevant to tactical decisions) that were not observed 5.2.3(D) Amount of correctly observed tactical decision input data 5.2.3(E) Amount of incorrectly observed tactical decision input data 5.2.3(F) Amount of available tactical decision input data not observed
CHARACTERISTICS	<u>Signature Locations</u> 5.2.1.1(A) Percentage of actual signatures located 5.2.1.1(B) Ratio of false signatures located to true signatures located 5.2.1.1(C) Distribution of distances at which actual signatures were located 5.2.1.1(D) Distribution of exposure times at which actual signatures were located 5.2.1.1(E) Distribution of Distances at which false signatures were located 5.2.1.1(F) Distribution of exposure times at which false signatures were located <u>Actual Threat Locations</u> 5.2.1.2(A) Percentage of actual targets located 5.2.1.2(B) Ratio of false targets located to true targets located 5.2.1.2(C) Distribution of amounts of signature displayed by actual targets that were located 5.2.1.2(D) Distribution of amounts of signature displayed by actual targets that were not located 5.2.1.2(E) Distribution of amounts of signature apparent signature associated with false target detections 5.2.1.2(F) Distribution of distances at which actual targets were located 5.2.1.2(G) Distribution of exposure times at which actual targets were located 5.2.1.2(H) Distribution of distances at which false targets were located 5.2.1.2(I) Distribution of exposure times at which false targets were located	<u>Information on What Was Observed</u> 5.2.2.1(A) Numbers of correctly observed identification ("what") data items 5.2.2.1(B) Numbers of incorrectly observed identification data items 5.2.2.1(C) Numbers of available identification data items not observed <u>Information on How Many Were Observed</u> 5.2.2.2(A) Numbers of correctly observed quantification ("how many") data items 5.2.2.2(B) Numbers of incorrectly observed quantification data items 5.2.2.2(C) Numbers of available quantification data items not observed <u>Information on Where & When Observations Were Made</u> 5.2.2.3(A) Numbers of correctly observed spatio-temporal ("where/when") data items 5.2.2.3(B) Numbers of incorrectly observed spatio-temporal data items 5.2.2.3(C) Numbers of available spatio-temporal data items not observed <u>Information on Enemy Actions Observed</u> 5.2.2.4(A) Numbers of correctly observed enemy action data items 5.2.2.4(B) Numbers of incorrectly observed enemy action data items 5.2.2.4(C) Numbers of available enemy action data items not observed	<u>Tactical Decisions Regarding Assessment of Degree of Threat to System</u> 5.2.3.1(A) Numbers of correctly observed system threat data items 5.2.3.1(B) Numbers of incorrectly observed system threat data items 5.2.3.1(C) Numbers of available system threat data items not observed <u>Tactical Decisions Regarding Assessment of System's Capability vis-a-vis the Threat</u> 5.2.3.2(A) Numbers of correctly observed system capability data items 5.2.3.2(B) Numbers of incorrectly observed system capability data items 5.2.3.2(C) Numbers of available system capability data items not observed <u>Tactical Decisions Regarding Assessment of Degree of Threat to Mission</u> 5.2.3.3(A) Numbers of correctly observed mission threat data items 5.2.3.3(C) Numbers of available mission threat data items not observed

Figure 18. BIFV Surveillance: Product-Oriented Measures

taxa associated with that performance element because the formulation of tactical decisions is an integral part of the exercise of command. Now, however, the key question would be, "How well does the system formulate its tactical decisions, given the information available?" The measures needed to address that question would focus on the kinds of decisions made, the decision algorithms used, the volumes of decisions made, their correctness, their timeliness, etc. In short, different sets of measures might derive from a common system taxon, depending upon the performance element of interest. The basic point is that the taxa are abstractions of measures. The concrete specification of the measures they represent depend on exactly which facet or element of the system's performance is being studied.

The measures hierarchy depicted in Figures 16, 17 and 18, of course, is an idealized set. That is, no attempt has been made to determine the feasibility of using any of the measures, or to eliminate those that may require data that cannot be obtained under realistic circumstances. That "weeding out" activity properly belongs at a later stage in the overall measurement process. The purpose of the taxa is to guide the analyst in identifying and organizing a set of measures that, if they can be used, would answer all the research questions at hand. The taxa themselves shed little or no light on the practicality of those measures.

There is no conclusive test or set of standards that can be used to judge the merits of the "Surveillance" measures hierarchy. The true merits of any measure can be known only when the measure is actually employed under the intended circumstances. Nevertheless, the measures themselves appear intuitively to be well suited to assess the BIFV Squad's performance of surveillance. The measures would allow the analyst to proceed in a careful and logical step-by-step fashion. Applied in the proper sequence, they would address the following kinds of questions:

- What capabilities does the BIFV Squad possess in the area of surveillance?
- What surveillance capabilities did the system actually use in this particular measurement application?
- How were these capabilities affected by the environmental and other circumstances that pertained to this particular measurement application?
- What procedures did the system actually use to apply its surveillance capabilities?
- How did these procedures differ from the prescribed surveillance procedures?
- How did the environmental and other circumstances affect the surveillance procedures?
- For what specific applications were the surveillance procedures conducted?

- Was sufficient and appropriate information or other input supplied to those applications through surveillance?

- What specific deficiencies were found in the information/input provided by surveillance?

Achieving the ability to answer questions such as these in every analytic application would constitute substantial progress in the state-of-art of human-machine systems measurement. In this specific instance at least, the APM has produced a measures set that apparently is structured around the right kinds of research questions, and that possesses the logical sequential organization required to address those questions.

2. Derivation of Measurable Performance Objectives for the BIFV Training System (BIFVTS)

a. General Conditions

In this second sample illustration of applying the APM for Measurement, the focus is shifted to the training system associated with the BIFV. The information in these paragraphs summarizes a more extensive and detailed discussion reported in an earlier project document (Bloom, et al., 1982, Section IIC and Appendix A). Using the training system hierarchical structure defined earlier in this report, and illustrated in Figure 9, this APM application was conducted for the purpose of deriving measures to assess how well the Design subsystem of the BIFVTS specifies the testing of gunner trainees.

b. Determine the Hierarchical Structure in Which the System of Interest is Imbedded

Figure 19 shows the system hierarchy for the BIFVTS--that is, its relationship to other training systems. Every training system can be conceived of as depicted previously in Figure 9, with six subsystems (Command, Design, Enabling, Emplacement, Logistics and Delivery).

The BIFVTS Command subsystem is operated and equipped by the BIFV Task Force, an ad hoc subsystem of the U.S. Army Infantry School. The BIFV Task Force has been created and staffed to exercise overall responsibility for the design, development, testing, and final production and dissemination of BIFV training. The specific immediate responsibilities of the Task Force are to:

- Identify the specific skills and knowledge required of BIFV operators.

- Develop BIFV training strategies.

- Establish new equipment training (NET) for the BIFV.

- Administer, monitor, and evaluate all BIFV training development, testing, and production.

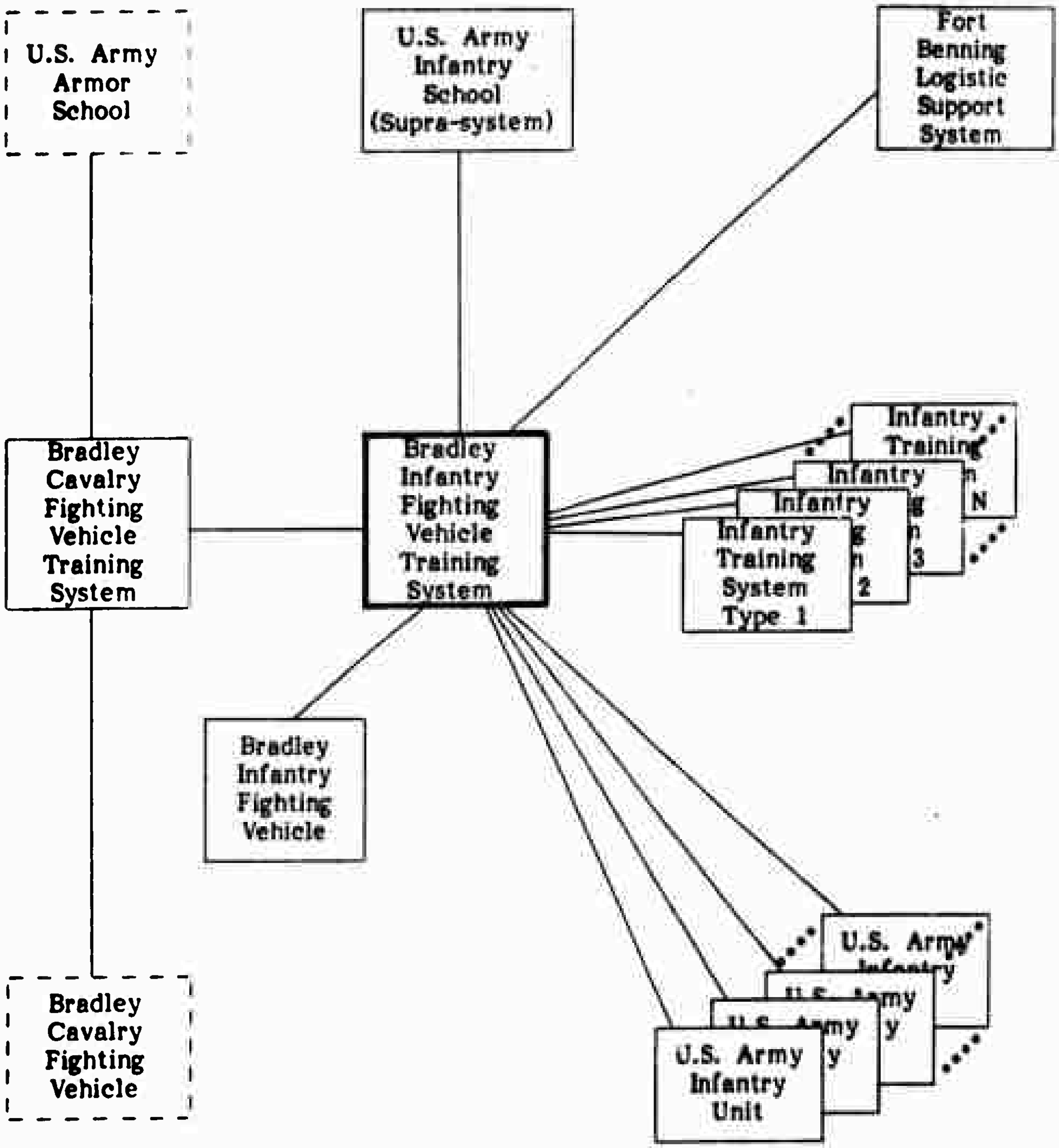


Figure 19. Major Systems Interacting with BIFVTS

The reader will recognize that several of the above-listed responsibilities are actually training design functions. Indeed, the BIFVTS Design subsystem also is operated (at present) solely by members of the BIFV Task Force. Their current design work is oriented toward the production of five distinct curricula:

- An "add-on" course for Skill Level 1 BIFV Soldiers (MOS 11M10).

- A Basic Gunnery Course (for Skill Level 2 Soldiers [MOS 11M20] and some Skill Level 1 Soldiers).

- A BIFV Commander's Course (for Skill Levels 3-5 [11M30, 11M40, 11M50] and for officer grades 01-05).

- A transitional new equipment training (NET) course covering the above-listed skill levels.

- A Master Gunner's Course.

The Master Gunner's curriculum principally is intended as an input to the BIFVTS Enabling subsystem. One E7 or E8 from the S3 section of each BIFV mechanized infantry battalion will receive Master Gunnery training, as will one E6 from each BIFV company. The Master Gunner's duties include the administration, supervision and delivery of Basic Gunnery training within his or her unit. The Master Gunner, in effect, will be a field facilitator/administrator within BIFVTS. Other current or planned operations within the BIFVTS Enabling subsystem include the organization and deployment of a team of facilitators to support new equipment training on a transitional basis as the BIFV is introduced into operational units; familiarizing selected mechanized infantry instructor/facilitators with the emerging BIFV curricula; and delivering Mastery Gunnery training. The Enabling subsystem must have the potentiality for insuring that adequate instructional skills resources are provided for BIFVTS Delivery applications.

The BIFVTS Emplacement subsystem is responsible for the design and selection/fabrication of all audiovisuals and other learning aids necessary to support implementation of the various curricula, and for the acquisition or construction and preparation of all sites at which learning activities will take place, whether in a classroom or field setting. One important element of this responsibility will be the design and construction of gunnery practice ranges. The range requirements presently envisioned include:

- Firing port weapons range
- BIFV Basic Gunners range
- BIFV Squad subcaliber range
- BIFV Squad qualification range
- Platoon qualification attack range
- Platoon qualification defense range

Note that all of the BIFVTS Emplacement subsystem's performance requirements derive from the need to insure that all facilities and

materials necessary to support delivery of BIFV training are available and operable at the times and places needed.

The BIFVTS Logistics subsystem presently is operated solely as a component of the Fort Benning logistic support system. In time, increasingly greater shares of the operation of that subsystem will be exercised by various mechanized infantry units in the field.

The BIFVTS Delivery subsystem will allow and insure that learning takes place in the contexts of the various curricula produced by the Design subsystem. Soldiers and officers will carry out prescribed sensory activities, guided and assisted by facilitators, and will achieve the specified performance objectives applicable to their BIFV operational assignments.

BIFVTS thus is a well structured training system, possessing functionally oriented subsystems compatible with the general training model and pursuing a broad range of administrative, developmental, and delivery goals to support the introduction of the new BIFV into the mechanized infantry. It does not detract at all from that image to note that BIFVTS can also be viewed as a loose consortium of smaller scale, relatively independent training systems that pursue more narrowly defined goals. These smaller systems are organized around the five BIFVTS curricula now in development. These systems may be denoted as:

- The BIFV NET System
- The Basic BIFV Soldier Training System
- The Basic BIFV Gunnery Training System
- The Master BIFV Gunnery Training System
- The BIFV Commander Training System

In order to reduce the scope of this trial application to a practical level, the focus is narrowed to the Basic BIFV Gunnery Training System. Like all systems, this one operates in the context of an interactive system network of suprasystems, collateral systems, and subsystems. The network is shown in Figure 20. The Basic Gunnery system is subservient to such entities as the U.S. Army Infantry School, the Fort Benning Logistic Support System and, of course, the total BIFVTS. It interacts collaterally with the other four independent BIFV training systems and with portions of U.S. Army Infantry units, namely, those portions from which the E4's and E5's will be recruited as candidate gunners. It also interacts collaterally with the BIFV Carrier Team subsystem. That is the portion of the total BIFV system for which the gunner-learners are to become qualified as operators. And finally, the Basic BIFV Gunnery Training System has a fraternal (collateral) twinship with the Basic BCFV Gunnery Training System. The subsystems of Basic BIFV Gunnery Training are, of course, the six familiar subsystems of Command, Enabling, Design, Emplacement. Logistics, and Delivery.

The focus of analysis was narrowed even further by addressing only the Design Subsystem of BIFV Basic Gunnery Training. Figure 21 depicts the network of systems that interact most closely with the Design subsystem of Basic BIFV Gunnery Training. As in any training system,

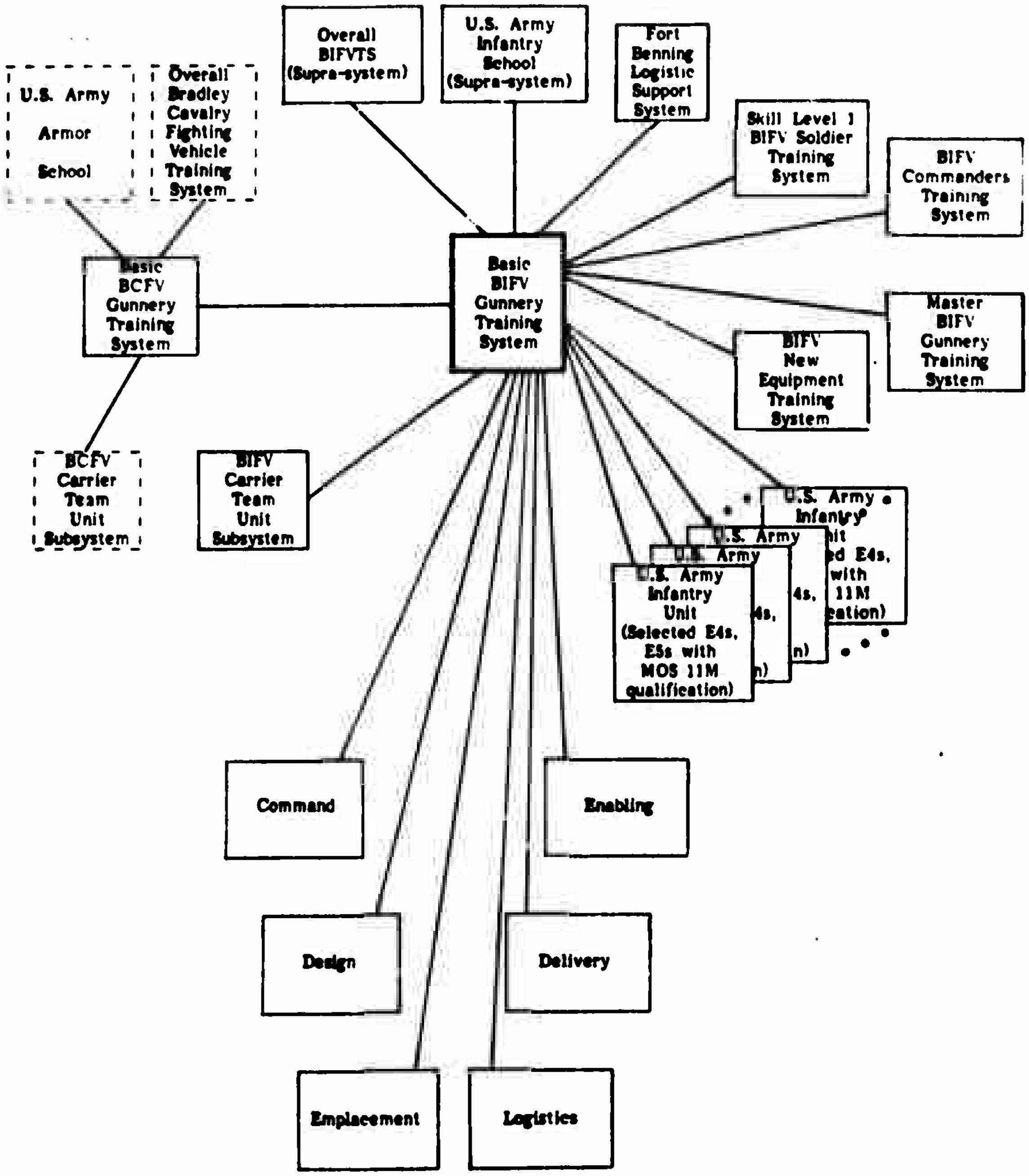
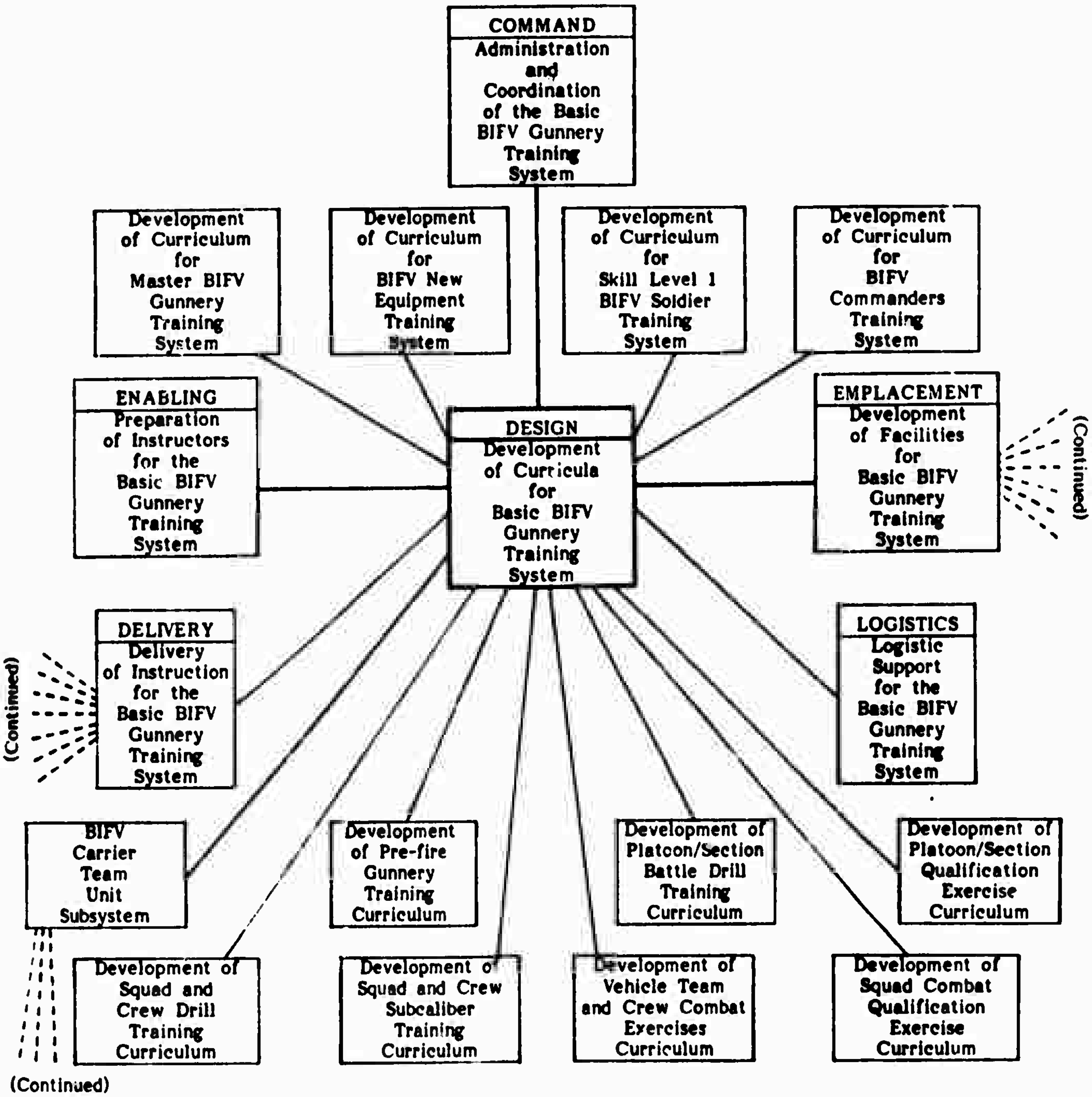


Figure 20. Major Systems Interacting with the Basic BIFV Gunnery Training System



System of Interest: The Design Subsystem of the Basic BIFV Gunnery Training System

(Continued →)

Figure 21. Sample Hierarchical Structure Centered on a Subsystem of a Training System

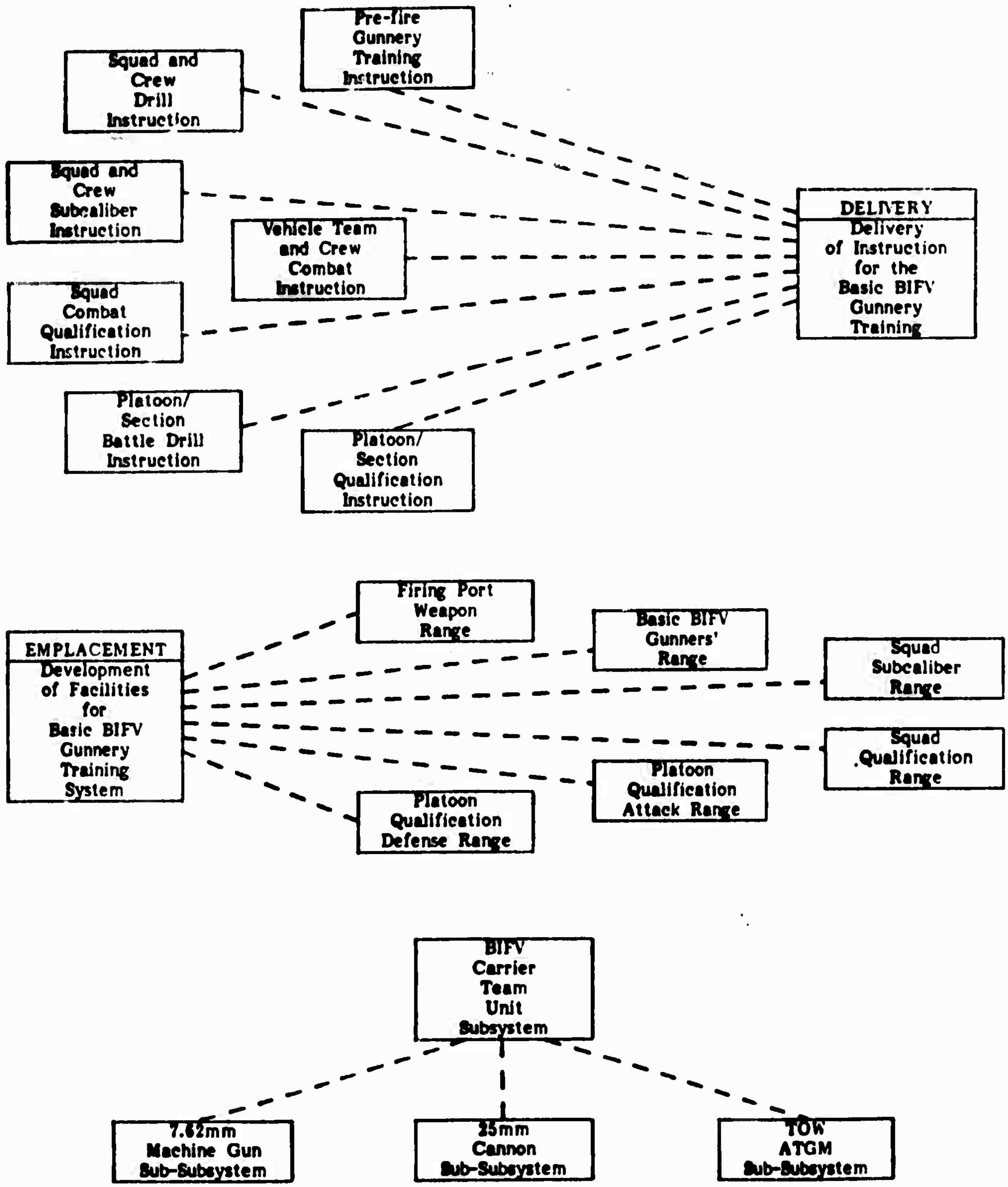


Figure 21. Sample Hierarchical Structure Centered on a Subsystem of a Training System (Concluded)

Gunnery Training Design is subservient to the Command subsystem, and collateral to the Enabling, Emplacement, Logistics, and Delivery subsystems. Key sub-subsystems of both Emplacement and Delivery have been included in Figure 21 to emphasize the special gunnery instruction and practice requirements that must be reflected in Design's products. Gunnery Training Design is also collateral to the Design subsystems of the other BIFV Training "packages." This is because all of those packages share some performance objectives, learning activities, etc., with gunnery training.

The sub-subsystems of Gunnery Training Design correspond to the thus far identified segments of the gunnery curriculum. These represent the sequential stages of learning through which BIFV gunner-learners must pass to become fully qualified. The initial stages stress individual training; the latter, team training.

c. More About the Measurement Application: Specification of Gunner-Learner Testing

Having selected the Design subsystem of Basic BIFV Gunnery Training as the system of interest for this trial, it remains to select an issue of focus for the application (i.e., an assessment of how well Design meets some limited aspect of its performance requirements). Ultimately, all assessments of training system or subsystem performance must supply some portion of the answer to this fundamental question: Did the learners learn what they were supposed to learn?

Design's basic job is to provide training specifications. It specifies what is to be learned, the context of learning, and the learning activities. One sub-issue of specifying learning activities was selected for this trial application: specifying gunner-learner testing. The other sub-issues of that heading are: specifying gunner-learner preparation activities; specifying activities for making presentations (or demonstrations) to gunner-learners; and specifying gunner-learner application (or practice) activities. Virtually all learning theorists agree that preparation, presentation, application, and evaluation (or testing) constitute the four classes of learning activities. The issue of how well a Design subsystem specifies learner testing materials and procedures is of special importance in any training system. No training system can afford to allow its Design subsystem to produce poor measures of learners' achievements. The Basic BIFV Gunnery Training System is no exception.

d. Begin Applying the APM to the System of Interest to Derive Performance Attributes and Measures

Before moving on to the next step in this trial application, in which particular performance taxa associated with learner testing specification will be identified, it is worthwhile to set the stage by informally reviewing some of the requirements and implications of learner testing in any training application. The following, at least, seem almost self-evident:

- Testing must be objectives-referenced

  The purpose of testing is to evaluate learners' progress toward or achievement of the performance objectives, i.e.,

that which is to be learned. No performance objective should go untested. No test that does not relate to some performance objective should be included.

- <u>Testing must be criteria-referenced</u>

  It is not enough that a test simply requires the learner to exercise the behavior called for in a performance objective. The test must disclose whether the behavior is performed "well enough" to satisfy learning needs.

- <u>Some kind of pre-training testing is necessary</u>

  All training assumes some prerequisite behavior. If nothing else, it is always assumed that the learner is able to carry out the sensory activities called for in the training. Many training applications admit the possibility that some learners may already have achieved certain of the specified performance objectives. There is no point in commencing training unless the learner first is tested to insure that he or she possesses the assumed prerequisites. A very informal test might suffice for that purpose, perhaps only a records check or even a cursory visual examination of the learner, but some testing for prerequisites surely is needed. When there is reason to believe that some learners may already have achieved the learning objectives, pre-testing of those objectives also will be necessary.

- <u>Some testing for feedback is necessary</u>

  Testing is, after all, a <u>learning</u> activity. Learners need to know how well they are doing in order to progress and persevere. Any training system should provide at least some testing for the purpose of feeding back progress and diagnostic information to the learners.

- <u>Testing must diagnose learning deficiencies</u>

  It is not sufficient that tests disclose that a learner cannot perform the intended behavior. In order to provide meaningful feedback to the learner and to facilitate subsequent improvement of the curriculum and the delivery, tests that diagnose the specific ingredients of substandard learner performance must be included in the specifications. Only then can the learner's performance be corrected and brought up to standard.

- <u>Testing must be reflective of on-the-job performance</u>

  The tests specified must require the learners to manifest the job-relevant behaviors under job-relevant conditions. The testing conditions should resemble job conditions as

closely as possible, since the test outcome otherwise may not be a valid predictor of the learner's job performance.

- <u>Some kind of qualification testing is necessary</u>

  No learner should be "certified" as having successfully completed training unless he or she demonstrates, through testing, that the performance objectives have been achieved. Depending on the circumstances of the particular training experience, the qualification testing might be formal or informal, but some testing surely is needed.

The preceding list probably would occur to any evaluator interested in measuring the adequacy of a Design subsystem's specification of its learner testing program. With that list in mind, the next step is to review the Design subsystem performance taxa of Appendix A for relevance to measuring the adequacy of specifying the gunner-learner testing program.

Two hundred and eighty-one taxa of Design Subsystem performance requirements are listed in Appendix A. These are distributed among the three aspects of performance (potentialities, processes, and products) and across the three levels of system description (objectives, functional purposes, and characteristics). Some of the 281 taxa are relevant to evaluation of a Design Subsystem's performance in specifying learner testing. Others are not. At the present stage of development of the APM, well defined procedures for determining which taxa do or do not bear on a given measurement application are yet to be established. Indeed, one purpose of this trial application was to add to the base of experience from which such procedures may be derived. Currently, assessment of taxa relevance is a "judgment call" by an analyst or team of analysts working together. The thought process can be described as follows: "Here we have some aspect of this sytem's performance, and over here we have a performance taxon for the system. That taxon represents a particular requirement that the system is supposed to satisfy. Suppose the system does a bad job in trying to satisfy that requirement. Might that have any bearing on the particular aspect that we are studying?" If the analyst concludes that the answer is "yes," the taxon in question would be included among the subset from which measurement issues and implications, and ultimately measures, will be derived. If the answer is "no," the particular taxon will supply no input to the measurement application at hand.

Identification of relevant taxa, then, is a step-by-step march through an entire system taxonomy, during which each taxon is picked up in turn, examined, and finally accepted or rejected in accordance with whether or not it appears to the analyst to have something of interest to say. This process can be streamlined somewhat, simply by examining only the characteristics-level taxa. If a taxon on the characteristics level is found to be relevant to the particular measurement application, then the functional purposes-level taxon from which it derives also must be relevant. A characteristics-level taxon, after all, is simply a detailed performance requirement that the system must satisfy if it is to achieve the related

functional purpose. Thus, the functional purpose must be subsumed under the aspect of performance being studied. Similarly, if a functional purposes-level taxon is relevant to the measurement application, so must be the objectives-level taxon from which it derives. The functional purpose, after all, is only a required application of the basic potentiality, process, or product defined on the objectives level. For example, if the analyst in using Appendix A were to conclude that taxon number 2.1.3.1 (a characteristics-level process requirement) is of significance to the measurement application, he or she would automatically know that taxa 2.1.3 and 2.1 (its functional purposes-level and objectives-level antecedents) also are relevant.

An examination was made (Bloom, et al., 1982) of every characteristics-level taxon of potentiality of the general Training Design subsystem for possible relevance to assessment of the subsystem's performance in specifying learner testing. Rationale for concluding whether an individual taxon is or is not relevant to the measurement issue is presented there. Similar (but undocumented) examinations were made of the process and product taxa. The final conclusion of these examinations was that 119 of the 281 taxa are relevant to evaluation of the Design Subsystem's specifications of learner testing. Those relevant taxa form 14 taxonomic subsets, of which 5 are potentialities, 3 are processes, and 6 are products. Figure 22 is a sample of 4 of the 14 subsets.

Alongside each of the evaluative issues arrayed in Figure 22, the reader will find a set of attributes deemed to be relevant to the particular issue. Each attribute is a concrete element of the Design subsystem's work. It is something that can be seen, examined, submitted to analysis, taken apart, etc. In short, each attribute is something that is measurable. Further, each attribute is something that, when measured, can supply a portion of the answer to the question posed in the evaluative issue.

An example may help to clarify the relationship between issues and attributes. Consider the fifth issue in Subset No. 6 (Figure 22), "Does the system accurately identify the physical skills that BIFV gunners must acquire to perform their tasks, so that appropriate tests of physical skills may be specified and developed?" This issue arises from a characteristics-level process, i.e., the analytic process used to identify the physical skills learners must acquire in order to serve as BIFV gunners. Clearly, tests of all required physical skills must be specified and administered as part of the gunner certification process. If the system's analysis is deficient, so that certain essential physical skills are not identified, or so that some irrelevant physical skills are mistakenly identified as essential, the testing specifications also will be deficient. As the design work progresses, the sponsors certainly would wish to know whether a thorough and accurate analysis of required physical skills is underway. In order to assess that issue, the evaluator would look first at the analytic methods the training designers are using to identify required physical skills. Are those methods appropriate to the analytic needs at hand? Are all of the data required for applicaton of those methods being obtained and used appropriately? Is there any fault to find with the way in which the training designers are applying those methods? As the analyses begin to produce results, the evaluator would examine the physical skills requirements identified. Are all of those skills really pertinent

Subset No. 2: "Establishing Performance Objectives"

	Issues	Attributes
1.2	Does the system have the ability to insure that all BIFV gunnery performance objectives will be identified so that they may be addressed in gunner testing specifications?	° Scope of information available concerning BIFV gunners' tasks ° Staff experience and qualifications in establishing performance objectives ° The planned approach to establishing BIFV gunnery performance objectives ° The resources allocated to establishing BIFV gunnery performance objectives
1.2.1	Can the system insure that all things BIFV gunners will be able to do after training will be stated, so that tests of all required abilities may be specified?	° The elements or factors of gunner abilities intended to be stated ° Intended formats for stating BIFV gunner abilities ° The plans for stating intended abilities
1.2.1.1	Can the system insure that the stated abilities will include definitions of the required gunner actions, so that the test specifications may address those actions?	° The types of performance actions intended to be defined ° The plans for defining actions required of BIFV gunners
1.2.1.2	Can the system insure that the stated abilities will include definitions of the appropriate conditions under which BIFV gunners are to perform the actions, so that the test specifications may reflect those conditions?	° The elements or factors of performance condition intended to be defined ° The plans for defining BIFV gunnery performance conditions
1.2.1.3	Can the system insure that the stated abilities will include definitions of the appropriate standards of acceptable performance of the BIFV gunner actions, so that the test specifications may incorporate those standards?	° Elements or factors of performance standards intended to be defined ° The plans for defining standards for BIFV gunnery performance actions
1.2.2	Can the system insure that the identified BIFV gunnery performance objectives will be applied to provide a basis for objectively assessing gunners' performances?	° Elements of the basis for assessment intended to be provided ° Plans for providing a basis for objectively assessing BIFV gunners' performances
1.2.2.1	Can the system insure that appropriate pretest items addressing the performance objectives will be developed, so that they may be included in the testing specifications?	° Types of BIFV gunnery pretest items intended to be developed ° Plans for developing BIFV gunnery pretest items
1.2.2.2	Can the system insure that appropriate posttest items addressing the performance objectives will be developed, so that they may be included in the testing specifications?	° Types of BIFV gunnery posttest items intended to be developed ° Plans for developing BIFV gunnery posttest items

Figure 22. Measurement Issues and Measurable Attributes Relevant to Evaluation of BIFV Gunnery Testing Specifications

Subset No. 6: "Analyze Tasks Selected for Training"

	Issues	Attributes
2.3	Does the system conduct a proper analysis of BIFV gunner tasks, so that appropriate tests of those tasks may be specified?	° The task analytic methods applied to the BIFV gunner tasks ° The scope of the task analyses conducted (i.e., factors determined in the analyses) ° The completeness of the BIFV gunner task analyses ° The accuracy of the BIFV gunner task analyses
2.3.2	Does the system accurately identify the domains of learning involved in the BIFV gunner tasks, so that tests may be specified and developed in the proper domains?	° Methods employed to identify the domains of learning involved in the BIFV gunner tasks ° The domains of learning identified for each BIFV gunner task
2.3.2.1	Does the system accurately identify the knowledge that BIFV gunners must acquire to perform their tasks, so that appropriate tests of knowledge may be specified and developed?	° Methods employed to identify the the knowledge requirements associated with BIFV gunner tasks ° The BIFV gunner task knowledge requirements identified
2.3.2.2	Does the system accurately identify the mental skills that BIFV gunners must acquire to perform their tasks, so that appropriate tests of mental skills may be specified and developed?	° Methods employed to identify the mental skills requirements associated with BIFV gunner tasks ° The BIFV gunner task mental skills requirements identified
2.3.2.3	Does the system accurately identify the physical skills that BIFV gunners must acquire to perform their tasks, so that appropriate tests of physical skills may be specified and developed?	° Methods employed to identify the physical skills requirements associated with BIFV gunner tasks ° The BIFV gunner task physical skills requirements identified
2.3.2.4	Does the system accurately identify the attitudes that BIFV gunners must acquire to perform their tasks, so that appropriate tests of attitude may be specified and developed?	° Methods employed to identify the attitudinal requirements associated with BIFV gunner tasks ° The BIFV gunner task attitudinal requirements identified
2.3.3	Does the system accurately identify the conditions for learning associated with the BIFV gunner tasks, so that appropriate tests may be specified and developed for assessing candidate gunners' qualifications?	° Methods employed to identify the conditions for learning the BIFV gunner tasks ° Types of conditions for learning identified for each BIFV gunner task
2.3.3.1	Does the system accurately identify BIFV gunners' prerequisite knowledge, so that appropriate tests of the knowledge prerequisites may be specified and developed?	° Methods employed to identify the prerequisite knowledge required for learning the BIFV gunner tasks ° Knowledge items identified as prerequisite for learning the BIFV gunner tasks

Figure 22 (Continued)

Subset No. 10: "Stated Performance Objectives"

	Issues	Attributes
3.2	Does the system produce accurate and complete statements of the performance objectives that BIFV gunners must achieve in order to be qualified for that job, so that tests of gunners' qualifications may be specified?	° The BIFV gunner performance objectives that are stated ° The format of the statements of BIFV gunner performance objectives ° The completeness of the performance objective statements ° The accuracy of the performance objective statements
3.2.1	Does the system produce exact definitions of what the gunner-learner are expected to achieve through training, so that tests of thoe achievements may be developed?	° The gunner-learner achievements that are defined ° The factors included in the definitions of gunner-learner achievements
3.2.1.1	Does the system produce correct specifications of the capabilities that gunner-learners are expected to achieve?	° Capabilities specified for achievement by BIFV gunner-learners
3.2.1.2	Does the system produce correct specifications of the actions that the gunner-learners are to execute to demonstrate the capabilities?	° Actions specified for execution by BIFV gunner-learners ° Observability of the actions
3.2.1.3	Does the system produce correct specifications of the objects that are to result from the execution of the actions by the gunner-learners?	° Objects specified as results of the action executions by BIFV gunner-learners ° Measurability of the objects
3.2.1.4	Does the system produce correct specifications of the circumstances under which the gunner-learners are to execute the actions to produce the objects?	° Circumstances specified for execution of the actions by BIFV gunner-learners
3.2.1.5	Does the system produce correct specifications of the tools and equipment BIFV gunner-learners are to use in executing the actions?	° Tools and equipment specified for use in the execution of the actions by BIFV gunner-learners
3.2.1.6	Does the system produce correct specifications of the constraints to be imposed upon the execution of the actions by the gunner-learners?	° Constraints specified for the execution of the actions by the BIFV gunner-learners
3.2.1.7	Does the system produce correct specifications of the criteria to be used to judge the adequacy of the objects resulting from the actions executed by the gunner-learners?	° Criteria specified as standards of adequacy for the objects resulting from the gunner-learners' actions

Figure 22. (Continued)

Subset No. 13: "Tests"

	Issues	Attributes
3.5	Does the system produce appropriate tests for administration to BIFV gunner-learners?	° BIFV gunner-learner tests prepared ° BIFV gunnery testing applications/ requirements for which tests are prepared ° BIFV gunner behaviors for which the tests are prepared ° Relevance of the tests
3.5.1	Does the system produce appropriate tests for assessing the qualifications of candidate BIFV gunner-learners?	° Candidate gunner-learner qualifications for which tests are prepared ° Tests prepared for assessment of those qualifications
3.5.1.1	Do the candidate qualification tests provide adequate measures of the candidates' prerequisite abilities?	° Domains of learning addressed by the tests ° Actions elicited by the tests ° Objects intended to result from the actions elicited by the tests
3.5.1.2	Are appropriate procedures specified for applying the qualification tests to BIFV gunner candidates?	° Circumstances specified for the tests ° Tools and equipment specified for the tests ° Constraints specified for the tests ° Other aspects of applications procedures specified for the tests
3.5.1.3	Are appropriate standards for qualification as BIFV gunner specified for the candidate qualification tests?	° Specific standards specified for the qualification tests
3.5.2	Does the system produce appropriate tests for assessing requirements for tailoring the instruction to accepted BIFV gunner-learners?	° BIFV gunnery abilities for which tailoring tests are prepared ° Tests prepared for assessment of needs for tailoring instruction to fit gunner-learners' abilities
3.5.2.1	Do the tailoring tests provide adequate pre-training measures of accepted BIFV gunner-learners' abilities?	° Domains of learning addressed by the tests ° Actions elicited by the tests ° Objects intended to result from the actions elicited by the tests
3.5.2.2	Are appropriate procedures specified for applying the tailoring tests to accepted BIFV gunner-learners?	° Circumstances specified for the tests ° Tools and equipment specified for the tests ° Constraints specified for the tests ° Other aspects of applications procedures specified for the tests
3.5.2.3	Are appropriate standards for tailoring instruction specified for the BIFV gunnery tailoring tests?	° Specific standards specified for the tailoring tests
3.5.3	Does the system produce appropriate tests for measuring what gunner-learners have achieved as a result of BIFV gunnery training?	° BIFV gunnery abilities for which achievement tests are prepared ° Tests prepared for assessment of BIFV gunner-learners' achievements

Figure 22. (Concluded)

to BIFV gunnery operations? Are there any essential skills that haven't been identified in this analysis? Are there any skills that the designers have labelled "physical" that really are "mental?" Based on these and similar considerations, the evaluator can form a well reasoned judgment about the accuracy of the designers' approach to identifying physical skills requirements. That reasoned judgment will be based on measures applied to the two concrete attributes, viz., the analytic methods of skills identification and the identified skills themselves.

The evaluative issues thus lead to measurable attributes, and the attributes in turn lead to measures of performance and effectiveness. The question is: How does all this "leading" proceed? How does one discern the attributes in the issues, and how does one derive the measures from the attributes?

No precise or even preliminary guidelines, algorithms or heuristics for extracting attributes from issues have thus far been developed. A major purpose of this trial application of system performance taxonomization to evaluating BIFV Gunnery testing specifications is to generate an experiential base from which such guidelines can begin to be derived. But in very general terms, the analyst's thought process in searching for the attributes of a particular issue relevant to testing specification can be sketched this way:

> "Here is an issue that bears on how well the BIFV Gunnery Design Subsystem can define (or has defined) gunner testing specifications. I'm supposed to suggest a way of answering the question posed in this issue. First, I have to ask myself: Which of the subsystem's people, resources/equipment, and procedures are involved in this issue? Next, what qualities or characteristics do those involved people, resources/equipment, and procedures have to possess, or produce in their work, if this issue is to be resolved affirmatively? Finally, what concrete, observable factors associated with those people, resources/equipment, procedures, or their work can I examaine to determine whether those qualities or characteristics are present?"

The concrete, observable factors uncovered by the analyst are the attributes associated with the issue in question. The mental process outlined above was applied to each of the 119 performance-related issues deemed relevant to evaluation of BIFV gunner testing specifications. A sample of the outcome is the set of attributes presented along with the issues in Figure 22.

If the reader will accept the attribute set given in Figure 22 as being at least illustrative of the bases from which the evaluative issues can be addressed, attention can now turn to the derivation of measures from attributes. A measure, in most general terms, is a judgment or appraisal about the thing-being-measured. Measures applied to system attributes derived from various taxa of performance thus are judgments or appraisals of performance. Each such measure contributes some small bit of wisdom or insight about the total performance of the system-being-measured. Every measure "looks" at its attribute in its own unique way, and "weighs" the attribute on its own unique scales. Collectively, the measures are intended to

determine whether the attribute is "good enough" to meet the demands of the performance requirement from which it derives. Individually, each measure focuses on some particular aspect or dimension of "goodness."

How does one measure whether a set of knowledge is "good enough." First, one specifies or states exactly what is known, i.e., the contents of the set of knowledge. Next, one identifies missing elements in the set of knowledge, i.e., facts or other information that should be known, but aren't. Finally, one identifies inaccuracies in the set of knowledge, i.e., supposed "facts" and other information that are not true. This is a roundabout way of saying simply that a person's knowledge of a given subject might be "bad" in any of three ways:

- the person might know nothing about the subject; or
- might know some things but not others; or
- might "know" some things wrong.

A combination of the last two is also possible.

In the specific context of the Design Subsystem's knowledge of the BIFV Gunner Tasks, the evaluator would need to determine, first, whether the subsystem knows anything about any of the tasks; second, whether some tasks are unknown to the subsystem; and, third, whether some of the "known" tasks are in fact not tasks required of BIFV gunners. Each of those determinations provides a separate judgment or appraisal of the goodness of the scope of information the Design Subsystem proposes to use as the basis for establishing BIFV gunnery performance objectives. That is, each is a separate measure of that one attribute of the system's potential for establishing objectives. The BIFV Task Force, in fact, has assembled a very comprehensive task data base which helps to meet the Potentiality aspects of this exercise.

Consider another example in the context of this same performance potentiality. Along with having good information about gunnery tasks, the Design Subsystem must have people who are qualified to do the job of establishing performance objectives. The staff's experience and qualifications thus constitute another attribute of the system's ability to produce well founded objectives. If their qualifications aren't "good enough," the system's ability to establish objectives also won't be good enough.

How does one measure the "goodness" of an individual's or team's qualifications for doing a particular job? When the job is relatively simple and of short duration, a candidate's qualifications sometimes can be measured by requesting him or her to actually do the work in question, on a sample basis. A typing test, for example, often is administered to candidates for a secretarial position. Then, actual job performance measures (e.g., words typed per minute, percentage of errors, etc.) can be applied to the sample work and used as job qualification measures. However, when the work is complex, cerebral and non-routine, this approach may not be practical. In such cases, clinical judgments usually are employed to appraise the candidate's qualifications. Subject-matter experts review resumes of the available candidates' experience and training relevant to the job to be filled, interview

personal references named by the candidates, perhaps examine the products delivered by the candidates during previous assignments similar to the job to be filled, and maybe interview the candidates themselves to obtain greater insight concerning the skills and knowledge they could bring to the job. Each expert reviewer then produces an independent rating of each candidate, based on the reviewer's perception of the candidate's strengths and weaknesses. Such ratings often are placed on an interval or ordinal scale. Then, the expert reviewers meet as a group, report and explain their individual ratings, deliberate on and debate the issues raised concerning each candidate, and form a consensus rating of the qualifications of each.

This clinical approach can be applied to measure the Training Design staff's qualifications for establishing gunnery performance objectives. The appropriate measures would include the consensus rating of each individual proposed for assignment to the task of establishing objectives, and an overall consensus rating of the total proposed staff as a team for handling that task. Both types of consensus ratings should include or be augmented with detailed explanations of all identified personnel deficiencies bearing on the ability to establish objectives.

It is relatively easy to suggest measures for any given attribute. Unfortunately, it is quite something else to devise a general procedure for doing so in all cases. Within the scope of this current study, measures have been suggested for all of the issues and attributes of the four taxonomic subsets of Figure 22. These measures are arrayed in Figures 23 through 26. Each suggested measure has something of value to say about the "goodness" or "badness" of the attribute to which it relates. The measures suggested for each given attribute collectively try to say everything that is pertinent to the "goodness" or "badness" of that attribute. Nevertheless, it is quite possible (and probably very likely) that the measures sets shown in Figures 23 through 26 will undergo significant revision after a critical review by subject-matter experts.

3. Concluding Remarks Concerning the Two Trial Applications of the APM to Measurement of System Performance/Effectiveness

Clearly, much remains unproven at the conclusion of these trial applications. The final products are merely partial sets of measures for assessing very narrow aspects of the work required of the BIFV and its Gunnery Training Design Subsystem. Most glaringly, those measures are untried. No one has actually attempted to apply them, or even to verify that the information needed to generate them can be obtained. Those measures, moreover, derive from attributes that also are unproven. No attempt has even been made to demonstrate convincingly that the attributes stated really constitute all of the factors pertinent to each evaluative issue, and only those factors.

What, then, <u>has</u> been demonstrated? If nothing else, sets of measures have been produced that definitely are issues-oriented. It has been possible to proceed from a framework of basic performance requirements to a statement of exactly what requirements apply to a given measurement application. It has been shown that such requirements can be expressed in

Hierarchy Number 1: BIFV gunnery design subsystem potential for establishing performance objectives

Issues

1.2 Ability to insure that all BIFV gunnery performance objectives will be identified so that they may be addressed in gunner testing specifications

Attributes	Measures
Scope of information available concerning BIFV gunners' tasks	A. BIFV gunners' required tasks that are known (listing and description of each such task) B. BIFV gunners' required tasks that are unknown to the Design Subsystem (listing of each) C. Tasks that actually are not required of BIFV gunners, but which mistakenly are classified as required by the Design Subsystem (listing and description)
Staff experience and qualifications in establishing performance objectives	D. Reviewers' cumulative ratings of each Design staff member's training, experience and previous performance in establishing performance objectives for training (using a specified point allocation system for training, experience, etc.) E. Reviewers' overall assessment of total Design staff's qualifications (based on specified method of accumulating individual members' ratings)
Planned approach to establishing BIFV gunnery performance objectives	F. Essential steps missing from the plans (listing and description of each such step) G. Inessential steps included in the plans (listing and description of each) H. Inconsistencies/deficiencies in the sequencing of steps in the plans I. Reviewers' cumulative ratings of the soundness/workability of the plans (using a specified point allocation system)
Resources allocated to establishing BIFV gunnery performance objectives	J. Percentage of required person-hours proposed for allocation to establishing objectives K. Percentage of required materials/goods proposed for allocation to establishing objectives L. Percentage of required support services proposed for allocation to establishing objectives M. Ratio of dollar value of total resources proposed for allocation to establishing objectives to dollar value of total resources actually required

1.2.1 Ability to insure that all things BIFV gunners will be able to do after training will be stated so that tests of all required abilities may be specified

Elements or factors of gunner abilities intended to be stated	A. Essential elements of abilities intended to be included in the statements of BIFV gunner abilities (listing and description of each such type of element) B. Inessential elements intended to be included in the statements of BIFV gunner abilities (listing and description of each type) C. Essential elements of abilities not intended to be included in the statements of BIFV gunner abilities (listing and description of each type

Figure 23. Sample Measures Hierarchy Number 1

Hierarchy Number 2: BIFV gunnery design subsystem process of analyzing tasks selected for training

Issues

2.3 Conduct of analysis of BIFV gunner tasks, so that appropriate tests of those tasks may be specified

Attributes	Measures
Task analytic methods applied to the BIFV gunner tasks	A. Deviations between the methods actually applied and the methods specified in the plans for analyses (listing and description of each such deviation) B. Aspects or elements of the methods applied that are irrelevant to or inconsistent with the analytic purposes (listing and description of each) C. Aspects or elements missing from the methods applied that are essential for the analytic purposes (listing and description of each) D. Types of data needed for the methods that were not obtained (listing and description of each data deficiency)
The scope of the BIFV gunner task analyses conducted	E. Factors supposed to be determined from the task analyses that actually were not determined F. Factors irrelevant to the analytic purposes that were determined in the task analyses
Completeness of the BIFV gunner task analyses conducted	G. Relevant BIFV gunner tasks to which the analytic methods were not applied H. Factors missing from the analyses applied to other relevant BIFV gunner tasks
Accuracy of the BIFV gunner task analyses conducted	I. Inaccuracies in the input data obtained for application of the analaytic methods J. Specific misinterpretations of the analyzed data K. Specific aspects or elements of the analytic methods that were misapplied

2.3.2 Classification of BIFV gunner tasks in terms of the domains of learning they involve

Attributes	Measures
Methods employed to identify the domains of learning of the BIFV gunner tasks	A. Aspects or elements of the methods employed that are irrelevant to or inconsistent with identification of the domains of learning involved in a task (listing and description) B. Aspects or elements missing from the methods employed that are essential for identifying the domains of learning (listing and description) C. Input data required for the methods that are missing or insufficient (listing and description)
The domains of learning identified for each BIFV gunner task	D. Domains identified as involved in a task that actually are not relevant to that task (listing and description of each such incident) E. Domains not identified as involved in a task that actually are involved in that task (listing and description of each such incident)

Figure 24. Sample Measures Hierarchy Number 2

Hierarchy Number 3: BIFV gunnery design subsystem product consisting of stated performance objectives

Issues

3.2 **Production of accurate and complete statements of BIFV gunner performance objectives, so that tests of gunners' qualifications may be specified**

Attributes	Measures
The BIFV gunner performance objectives that are stated	A. Statements that define performance objectives that actually are not needed for BIFV gunnery (listing and description of each such statement) B. Performance objectives that actually are needed for BIFV gunnery that are not addressed in any of the statements produced (listing and description of each such objective)
The format of the statements of BIFV gunner performance objectives	C. Essential elements of performance objective statements not included in the format employed for stating BIFV performance objectives (listing and description of each missing element) D. Inessential/inappropriate elements in the format employed for stating BIFV performance objectives (listing and description of each such element)
The completeness of the statements of BIFV gunner performance objectives	E. Elements missing from the statements of particular BIFV performance objectives (tabulation of missing elements as a function of the stated objectives)
The accuracy of the statements of BIFV gunner performance objectives	F. BIFV performance objective statements that contain erroneous or inaccurate elements (tabulation of inaccurate elements as a function of the stated objectives) G. Description of the nature of the inaccuracies, for each stated objective

3.2.1 **Production of exact definitions of the BIFV gunner-learners' expected achievements as a result of the training**

Attributes	Measures
The BIFV gunner-learner achievements that are defined	A. Achievements defined that actually are not necessarily expected of BIFV gunner-learners during training (listing and description of each such achievement) B. Achievements not defined that actually are expected of BIFV gunner-learners during training (listing and description of each such achievement) C. Inexact or ambiguous elements in the definitions of BIFV gunner-learner achievements (listing and description) D. Inaccurate elements in the definitions of BIFV gunner-learner achievements (listing and description)
The factors included in the definitions of BIFV gunner-learner achievements	E. Factors included in the definitions that actually are irrelevant to the description of intended achievements of BIFV gunner-learners (listing and description) F. Factors missing from the definitions that actually are essential for describing intended achievements of BIFV gunner-learners (listing and description)

Figure 25. Sample Measures Hierarchy Number 3

Hierarchy Number 4: BIFV gunnery design subsystem product consisting of tests

Issues

3.5 Production of appropriate tests for administration to BIFV gunner-learners

Attributes	Measures
The BIFV gunner-learner tests that are prepared	A. Prepared tests that address each BIFV gunnery performance objective (listing and description as a function of each performance objective) B. Prepared tests that relate to no BIFV gunnery performance objective (listing and description of each such test)
BIFV gunnery testing application/requirements for which tests are prepared	C. Reviewers' ratings of the utility of each prepared test for each testing application/requirement (yes/no rating of each test for each application)
BIFV gunner behaviors for which tests are prepared	D. Listing of tests prepared for each behavior associated with each performance objective
Relevance of the tests	E. Deviations between the behaviors elicited by the tests and the behaviors that actually are to be addressed (listing and description of each such deviation)

3.5.1 Production of appropriate tests for assessing the qualifications of candidate BIFV gunner-learners

Attributes	Measures
Candidate gunner-learner qualifications for which tests are prepared	A. Relevant qualifications for which tests are prepared (listing and description of each such qualification) B. Relevant qualifications for which no tests are prepared (listing and description of each such qualification) C. Irrelevant "qualifications" for which tests are prepared (listing and description of each)
The tests prepared for assessment of the qualifications	D. Elements of each test that deviate from the qualifications actually required of acceptable gunner-learners (listing and description of each such deviating element) E. Probability that each test will be passed by candidates who actually do not possess the qualification being tested F. Probability that each test will be failed by candidates who actually do possess the qualification being tested G. Cumulative probability that an actually unqualified candidate will pass sufficient qualification tests to be accepted as a gunner-learner H. Cumulative probability that an actually qualified candidate will fail sufficient qualification tests to be rejected as a gunner-learner

Figure 26. Sample Measures Hierarchy Number 4

terms that permit concrete, tractable attributes to be defined. None of the attributes stems from any particular approach to system design. All of the attributes derive from the performance requirements that are common to all such designs. This is a critical point: it demonstrates that the APM at least is rooted firmly in valid measurement issues. Too often, evaluations of new systems are clouded by irrelevant and unfair comparisons with older design concepts. The basic question of whether the new system does what it is supposed to do sometimes is overlooked because the evaluators actually measure how the new system "looks" in comparison to older models. Conclusions based on such evaluations typically may suggest: "The system is no good because we've never done it this way before." That design-oriented philosophy of measurement suppresses technological breakthroughs. In the training sphere, for example, it prevents modern and effective methods of work site, learner-tailored instruction from playing their appropriate roles in the total learning environment, and it masks the relative ineffectiveness of the traditional, institutional methods of training.

It is a step forward to have shown that a measurement scheme can be kept free of artificial judgments of design. Use of the APM has forced rather complete taxonomies of performance requirements to be considered in measurement applications, more complete than a typical, less structured analysis would provide. It has also demonstrated the existence of generalized and also useful tax, an essential ingredient in constructing a "systems application science." Though much remains to be done to insure that the best measures always are identified, it has been shown that measures can be identified for these performance-oriented attributes.

III. APM APPLICATION PROCEDURES

A. General

The two intended applications of the APM are to specify the design of human-machine systems and to define measures of performance and effectiveness for those systems. As described previously, system design and system measurement deal with exactly the same issues. Those issues are the constituent requirements of system performance. The designer and the evaluator are (or should be) interested strictly in: the capabilities (potential performance) their system is supposed to have; the activities (process performance) it is supposed to carry out; and the goods and services (product performance) it is supposed to deliver. The designer's job is to see to it that the system does in fact meet all of its requirements for potential, process, and product performance within the environmental and design constraints imposed. The evaluator's job is to check on how well the designer's job is done. Their jobs must be performed as an interactive process.

To apply the APM, the designer and evaluator should follow the steps depicted in Figure 27. In Step 1, the analyst is required to define the purpose of this analysis, in terms that are as specific and confining as possible. This information will be used later in helping to assess which of the many system performance items (which may be presented to the analyst from a computer data base) are relevant to the present analysis. Specificity and narrowness of limits in defining the analytic purpose can help keep the ultimate number of design specifications or evaluation measures to a minimum.

Step 2 of the procedure requires the analyst to identify the overall class of systems to which the system of interest belongs. The purpose of this designation is to permit the computer to aid the user by presenting for review any known performance items, attributes, design specifications and measures that are stored in its data base from previous analytic efforts.

Step 3 allows the user to identify the specific system of interest so that, for computer-aided analyses, the proper identification automatically appears on all displays and printouts. This serves as both a record and a reminder of the application at hand.

In Step 4, the analyst is required to consider all the other "systems" which interact with the one of central interest. Interactions with suprasystems, collateral systems and subsystems call the analyst's attention to the fact that the system of interest must provide outputs to, and use inputs from, external entities. The requirements of those external entities thereby have an influence on performance requirements being developed for the system of interest. This step is not presently implemented on the computer-aided APM demonstration package.

Step 5 requires the user to construct system performance taxonomies in accordance with the 15-cell (5 Aspects x 3 Levels) matrix referred to

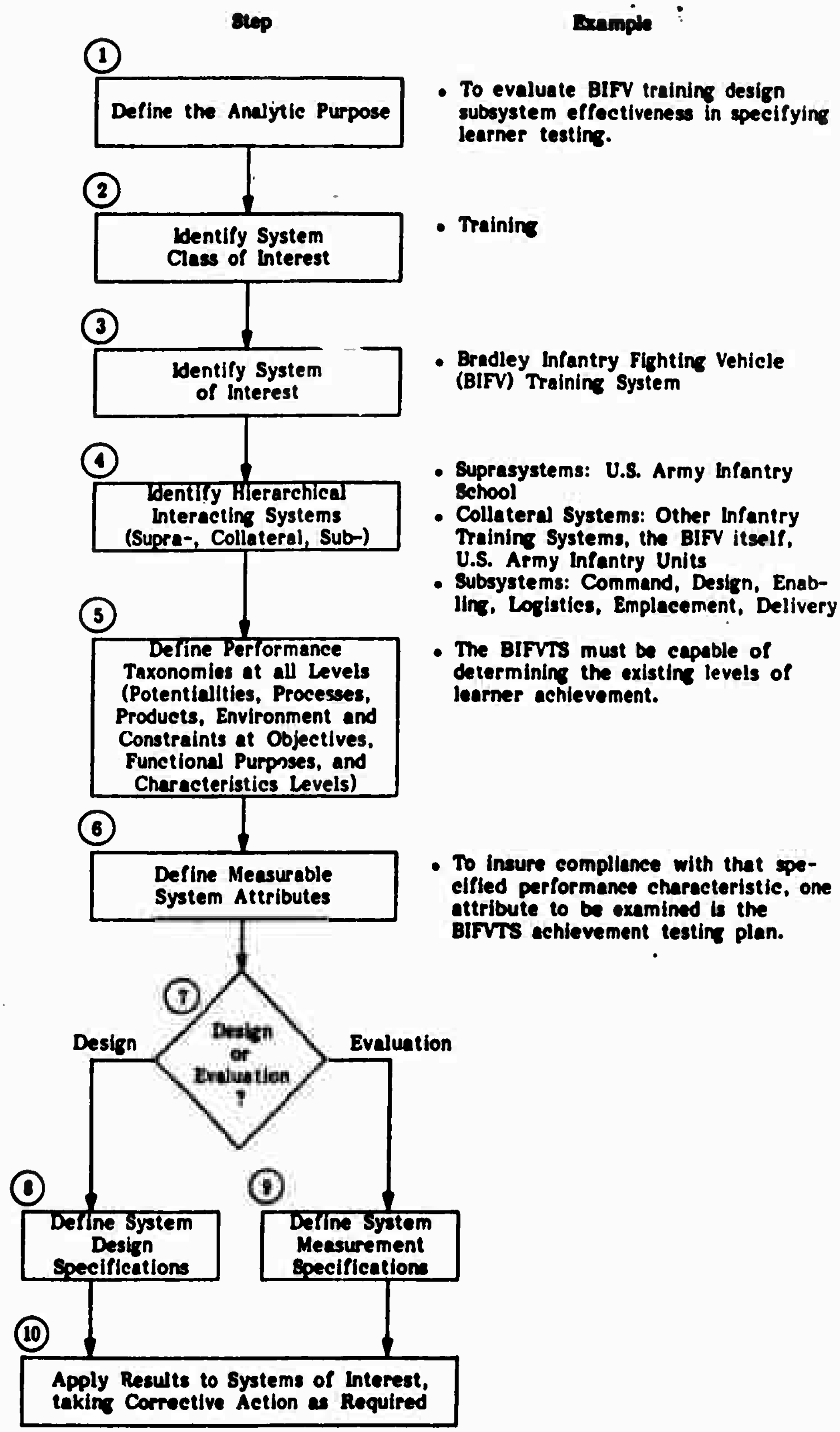


Figure 27. General APM Application Procedures

previously as the Systems Taxonomy Model (STM) portion of the APM. Because of the voluminous, equivocal and vital nature of this step, it is of special importance that the analyst be given systematic directions and a large data base of existing, representative taxa to aid in its satisfactory completion. In recognition of that need, the computer-aided APM demonstration package and this report (appendices) contain comprehensive performance taxa for several of the six defined training subsystems (for design, enabling and delivery, but not for command, logistics and emplacement). The number of performance items that are retained as relevant to a given analysis will depend upon the purpose of that analysis (see Step 1).

The task in Step 6 is to identify those system attributes that are both reflective of each performance requirement and susceptible to specification or measurement of some kind. Here, too, the user can be aided by having the opportunity to review existing, representative attributes that a have been derived from the system performance measures. The computer-aided APM demonstration package and this report (appendices) contain a sample of such representative attribute lists for training systems.

Step 7 is the point in the APM where the analyst decides what will be done with the relevant performance attributes that have been identified. It is here that the model divides into one procedure for developing design specifications and another procedure for developing measurement specifications.

In Step 8, the user acts on the choice to identify design specifications for the relevant performance attributes. Ideally, the analyst will state objective, operational criteria to be achieved by the designers in providing for the required system attributes.

In Step 9, the user acts on the choice to identify evaluation measures for the relevant performance attributes. The measurement specifications can be developed with the aid of the model and the existing sample of representative measures to be found in both the computer-aided package and this report (appendices).

Step 10 calls for the user to apply the results of this analysis to the system of interest, either in aiding its evolving design or measuring its operational performance. Comparisons of design specifications with performance measures can also result in decisions to modify the system, its performance requirements, its design specifications, its effectiveness measures, or all of these. This must result from the interactive design/evaluation processes referred to earlier.

Clearly, the cost-effective application of this model to typical military systems requires some kind of routinized procedure, such as the one illustrated by the APM demonstration package developed as a part of the present effort. The application of that computer-aided APM is described next.

B. The Computer-Aided APM

The ultimate computer-aided APM will help the analyst to design or evaluate the effectiveness of any (conceptual or real) system. The analyst will

take one of several approaches to working with the system of interest. If the system is totally different from any existing system, he will start out by defining new performance items (objectives, functional purposes, and characteristics). Then, the analyst will specify the attributes and measures (or the design specifications) for each of the performance items. Once this is accomplished, he might specify reasons for performing an analysis and associate each of these purposes with a set of characteristics. Printing the data set in a variety of formats as well as editing the data set for corrections and/or revisions will, of course, be possible.

If the system of interest is very similar to (but different from) an existing system, the analyst will be able to review, on a line-by-line basis, each of the performance items, design specifications, attributes, and measures for the existing similar system and decide whether to include these taxa in the new system unedited, edit the items for inclusion in the new system, or exclude them from the new system. Then, the analyst will be able to associate each of the performance items with appropriate measurement purposes, and print the data set in a variety of different formats.

Probably the most frequent use of the APM will be to analyze and/or review the design specifications for an existing system (any system which has previously been entered into the computer is an existing system). In this case, one might start by examining a specific measurement purpose for the existing system, including, excluding, editing, or otherwise reviewing individual taxa associated with the measurement purpose. Alternatively, the analyst might decide to review all of the performance items design specifications, attributes, or measures; or the analyst might decide to review a specific performance item, a specific attribute, and/or a specific measure. After completing this editing procedure, the analyst will have the opportunity to print out the results of his analysis.

Another application for the APM would be for an analyst to decide to analyze part of a system, but not the entire system. The analyst might decide, for example, to perform only 30 or 40 percent of the recommended measurements. In this case he would have the option to tell the computer which measures he would or would not perform. The computer would then tell him which performance items were going to escape untested, so that he could review, once again, his testing procedures.

This ultimate system would be implemented on a main-frame computer with adequate on-line disk storage for several systems. Analysts would have the opportunity to draw upon master files of taxa so that they could extract what they would need to construct their systems. Furthermore, they would have the ability to compare their system with a host of other systems to discover various performance items which they may have inadvertantly left out of their data sets. The ultimate system would be user-friendly, offering help as needed. It would come with an on-line tutorial program, and taxa for many systems. Furthermore, the system would be compatible with both touch-sensitive screens (to insure maximal user-friendliness) and keyboard entry devices (to avoid excluding users without touch-sensitive screens).

A demonstration model which illustrates many of the important features of the ultimate system for measurement (but not for design) was programmed in

PASCAL on an APPLE II PLUS Computer System with an 80-column VIDEX board. While companion volumes to the present report (Shapiro et al., 1983; and Shapiro, 1983) provide tutorial and operating instructions for the demonstration system as well as listings of the actual PASCAL code, Figure 28 presents an overall schematic flow chart of the demonstration system.

When the computer is first turned on, a title page appears on the display screen. As soon as an analyst presses a button on the computer's keyboard, he/she can choose to read instructions which explain the operation of the demonstration system in detail. The instructions are user-friendly in that they are written with minimal computer jargon and the computer refers to itself as "I" and to the analyst as "you." The analyst may branch through the instructions reading only those which are of interest.

Upon completing the instructions, the analyst selects which class of systems (e.g., Training, Communications) to work with (only Training is implemented). Then he/she selects a particular system (e.g., Bradley Infantry Fighting Vehicle Training System). Finally, he/she selects a subsystem (e.g., emplacement, delivery, or design). After the system class, system, and subsystem are selected, a menu of all available analytic procedures is displayed for analyst selection. The analyst might, for example, choose to Add, Modify, or Delete Measurement Purposes. Thus, he/she would define a particular measurement purpose (or use an existing measurement purpose). Then, the analyst would have the opportunity to associate relevant characteristics with the measurement purpose, or dissociate irrelevant characteristics.

Alternatively, the analyst might select to add, modify, or delete performance items (objectives, functional purposes, and characteristics) for the 5 x 3 matrix of the system. The analyst could also add, modify, or delete attributes and measures for any performance item. Whenever the analyst is performing a procedure, he/she has the option of making a paper copy of the taxa which he is analyzing at a given time. Furthermore, the analyst has the opportunity to print out all of the taxa for the subsystem of interest, or all of the taxa for a given measurement purpose. Samples of this printout for the design, enabling and delivery subsystems appear in Appendices A, B and C, respectively. The printouts present the subsystem (or the taxa which are relevant to a given measurement purpose for the subsystem) in a hierarchy; the aspects of the system (Potentialities, Processes, Products, Environmental Constraints, Constraints); the relevant objectives; and the functional purposes, characteristics, attributes, and measures for each objective. Each taxon bears a unique number which follows the general hierarchical plan. Other analytic procedures available include packing disk files more efficiently (a basic housekeeping function), reviewing instructions, stopping, or specifying the system class, system, or subsystem to be used for the remainder of the session.

The demonstration model is user-friendly. In addition to easy-to-read instructions, help messages are available in the initial program where one specifies which system he/she wishes to use, and which analytic procedure he/she wishes to perform. However, they are not available in other programs. The demonstration system is also very forgiving of typing errors. Whenever it

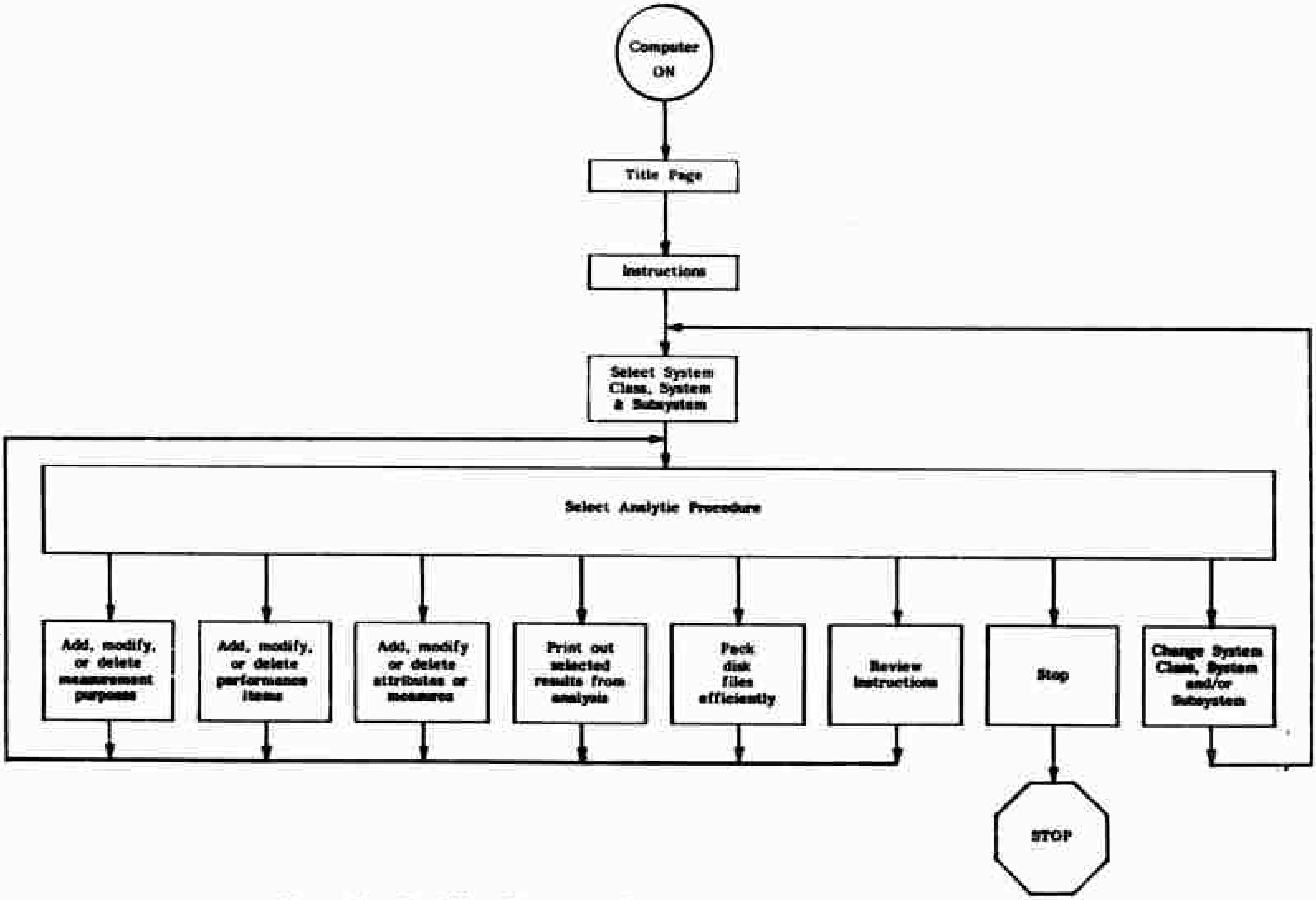


Figure 28. Simplified Flow Chart for Computer-Aided APM Demonstration System

catches an illegal response, it tells the analyst what the legal responses are. The system does, however, have certain very strict limitations. Most of these limitations are caused by the relatively slow processing speed of the Apple II Plus computer, and the relatively limited core and disk storage available on the Apple II Plus, as well as the attempt to avoid excessive use of machine-dependent code. A comparison of the specific limitations of the demonstration system and a list of features to be available in the ultimate system are presented in Figure 29.

Description	Ultimate Package (preliminary estimate)	Demonstration Package
STORAGE CAPACITY		
Number of SYSTEM CLASSES, SYSTEMS, & SUBSYSTEMS that can be ONLINE at the same time	50 each	1 each
Number of OBJECTIVES, FUNCTIONAL PURPOSES, and CHARACTERISTICS that can be specified for a given subsystem	5,000 total	900 total
Number of OBJECTIVES that can be specified for a given ASPECT	99	20
Number of FUNCTIONAL PURPOSES that can be specified for a given OBJECTIVE	99	20
Number of CHARACTERISTICS that can be specified for a given FUNCTIONAL PURPOSE	99	20
Number of ATTRIBUTES that can be specified for a given subsystem	2,000	200
Number of ATTRIBUTES that can be specified for a given PERFORMANCE ITEM (OBJECTIVE, FUNCTIONAL PURPOSE, or CHARACTERISTIC)	99	20
Number of MEASURES that can be specified for a given subsystem	10,000	400
Number of MEASURES that can be specified for a given ATTRIBUTE	99	20
Number of MEASUREMENT PURPOSES that can be specified for a given subsystem	99	5
Number of PERFORMANCE ITEMS that can be associates with a given MEASUREMENT PURPOSE	5,000	225
Number of characters allowed for description of a PERFORMANCE ITEM, MEASUREMENT PURPOSE, ATTRIBUTE, and MEASURE	400 each	80/Performance Item 68/Attribute & Measure 136/Measurement Purpose
Number of characters available for explanation of a given taxon	800	0
PROCESSING SPEED		
Execution time for disk searches and sorts	Fast	Slow
Printer speed for printing an entire data set	Fast	Slow
HELP MESSAGES		
Number of messages available	900	60
Ability to specify new help messages while using program	Online	Offline
Length of each message	8,000 characters	800 characters
Availability	Anywhere in programs	In 2 of the 6 programs

(continued)

Figure 29. Comparison between the Ultimate Computer Package and the Demonstration Package

Description	Ultimate Package (preliminary estimate)	Demonstration Package
ACCOUNTING FUNCTIONS		
Keep track of usage for each system class, system, subsystem, and help message	Online	Logbook
DISK BACKUPS		
Daily backup of each system modified during the day	Automatic	Manual process
Backups available upon request	Yes	Yes
FILE MODIFICATION		
Ability to modify a disk file for personal use without destroying the master file	Automatic	Manual recopy necessary before making changes
Restricting modification of master files to privileged accounts	Automatic	Keep master files in locked file cabinet
MEASUREMENT PURPOSE		
Ability to edit performance items, attributes and measures for a given MEASUREMENT PURPOSE	Yes	No
OVERHEAD		
Number of simultaneous users (either independent or interacting following a teacher's demonstration)	15	1
Power failure protection	Yes	No
DATA SETS SUPPLIED WITH PACKAGE	Many	3 subsystems
ONLINE MESSAGE FACILITY		
Allows analyst to send Computer Package Staff messages about system at any time	Yes	No
CODE EFFICIENCY		
Use search routine which is optimal for task at hand	Yes	No
DISPLAY UPDATES AFTER SMALL MODIFICATION TO TEXT	Single-line updates	Must reconfigure entire display
TUTORIAL PROGRAM	Online	In booklet form
SPECIAL MESSAGES		
After the print routine, displays the measures which ought to be used, and the computer asks, "Which measures do you really plan to use?" and shows which performance items were not analyzed as a result of the omissions.	Yes	No
In the attributes and measures specification program, computer reminds analyst (in generic terms) what ought to be measured for each performance item. Thus, potential measures are not neglected.	Yes	No

Figure 29. (Concluded)

IV. RELATIONSHIP OF THE APM TO OTHER MODELS*

A. Bases of Comparison

There are, of course, many "models" available for the development and evaluation of human-machine and training systems. Indeed, there are so many such models that it is difficult to list them let alone select an appropriate model for an application. These models tend (1) to be based on a variety of mathematical and descriptive bases, (2) to be specific system- and/or aggregate systems-oriented, (3) to concentrate on macro- or micro-levels or somewhere in between, and (4) to focus on parts of the total human resources in system problems. It is, therefore, not easy to place the APM within the general framework of human-machine and training systems models since that framework is, at present, not clearly defined and structured.

One way of looking at the APM is within some of the major acquisition and development steps for all military systems. In this chapter, six such steps are noted as follows:

- Human-machine system development procedures
- Human-machine system development
- Training system development
- Behavioral simulation models
- Logistic support analyses
- Test and evaluation methods

Thus, the emphasis here is on the possible use of the APM, as compared with other models, in some of the major events in system development. The question, then, is not so much the internal structure of the APM insofar as completeness, coherence, and validity but, rather, how relatively well it can be used in a comparison with other models and methods in the technical inventory.

With this approach, certain utility features of any model become paramount. Questions arise, such as: (1) How well does the model fit the system (or systems) under development? (2) What kinds of data are needed for the model to work well? (3) How much time and project resources are needed to use the model? (4) Does the model produce requirements and data useful in system development? and (5) What kinds of analytic skills are needed to apply the model (i.e., can it be used by normal project people or does it require very highly talented people who may or may not be available to the program)? These are all very practical problems which seem to determine to a great extent whether or not models are used in the system development project.

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B. System Development Procedures

The major single document that defines the procedures for the design and development of human-machine systems is MIL-H-46855B (Department of Defense, 1979) "Human Engineering Requirements for Military Systems, Equipment and Facilities." This general specification, and its subsequent revisions, has been in effect since 1968, and is presumably mandatory for all military system development projects. Basically, it provides a top-level procedure for analysis, design and development, and test and evaluation of all human-machine military systems and subsystems. In practice, many variations have been followed to implement the specification. Indeed, it was designed to allow for such variations consistent with differing weapon systems across the military services. The end goal of the specification is to attempt to assure that the human element of military systems is used properly and effectively.

The APM is totally consistent with the general objectives of MIL-H-46855B. The APM may, in fact, be considered an implementing and detailed model of that specification. The APM places primary emphasis, in its present form, on system, subsystem, and mission analysis (to use the terminology of MIL-H-46855B) and stresses "... the functions that must be performed by the system in achieving its mission objectives (which) shall be identified and described." (MIL-H-46855B: 3.1.1.a) Two major strengths may be noted in the APM process:

- An initial emphasis on system goals and objectives which forms the framework for all subsequent analysis, design, and test.

- A major requirement to evaluate all system and subsystem levels of potentialities, processes, and products.

Within each system level, specific answers must be given to the questions: What? (Objectives) Why? (Functional Purposes and How? (Characteristics) This is precisely the intent of the analytic steps in MIL-H-46855B; the APM is the most highly structured tool for accomplishing this objective currently available. Further, in its computerized form, it assists the analyst in rapid use of the model. Finally, the computerized APM is "user friendly," and takes into account a widely varying skill level among potential users.

With respect to model structure, the APM is consistent with standard system engineering methods which have been in use for the past 20 years (cf., Machol, 1965; Byrne, Mullally, and Tohery, 1969). Within that framework, the APM may be classified as:

- A descriptive model with, however, specific quantitative outputs in the measurement subsystem; and

- A static, multi-level model (cf. Niehaus, 1979) which can give rapid snapshots of the development status of the system insofar as human resources are concerned, as well as system performance implications.

On the latter point, a choice is available to system analysts between static and dynamic models. Dynamic models assume a time-varying, scenario-based simulation. At the present time, the APM is not constructed for this use although future development could make it so. Further, no explicit use has been made of a great number of optimization techniques (cf., Rouse, 1980) that might be used for human-machine systems problems.

While all systems models are concerned with measurement and measures, the APM appears to be unique in its stress on the methods for deriving specific and practical measures. Often, measurement is left to the skill of the analyst with the method undefined; APM requires a direct and explicit development of system and subsystem measurement. As will be noted, the data estimates so derived will be useful for many purposes.

C. Human-Machine System Development

The major purpose of MIL-H-46855B was to give a general, sequential method by which human-machine systems could be developed with careful emphasis--in the total systems context--on the use of the human element. As noted, the APM is a specific method for doing exactly that. While there are a number of particular techniques for human engineering development (cf., Meister, 1976), the APM appears to be the most comprehensive, thorough, and detailed method to date. It fulfills the data requirements for MIL-H-46855B, but goes beyond those requirements to specify training system requirements and provides basic data for logistic system support analyses.

Much practical experience tends to confirm the fact that systematic attention to human resources within the system development process varies enormously. The range is from very detailed and competent contributions to ignoring the human element altogether. The reasons for this are complex (cf., Carr, et al., 1980), but one problem has been the lack of methods that significantly answer all of the manpower, personnel and training questions that arise from a new system.

One method (Mackie, 1979) has organized the system development process into nine basic questions concerning the manpower, training, and personnel elements of the system:

1. How do various design concepts affect manpower and training requirements?

2. How do manpower and other evaluative criteria interact?

3. What numbers and types of personnel are associated with this system?

4. What is their projected availability?

5. Which design alternative best satisfies all criteria?

6. What operator and maintenance tasks are implied by this design?

7. What are the operational and maintenance training requirements?

8. What skill levels and numbers of operators are required?

9. What are the estimated personnel life-cycle costs to man the system?

The procedure also suggests the kinds of data that would be needed to answer these questions.

One way of evaluating the APM--or any other model framework for system development application--is to estimate the degree to which APM can answer these questions. Following the order of the questions as just given:

1. Alternative design concepts can be evaluated within successive runs of the APM with its major strength in its present form in personnel and training estimates.

2. Criteria interaction assessment should be particularly strong since the APM model requires careful delineation of goals and objectives with specific measurement dimensions.

3. There is no clear path, at present, in the APM to estimate numbers and types of personnel.

4. At present, APM does not take into account projected manpower availability, although it certainly could be expanded to do so.

5. Trade-off studies based on explicit criteria from APM should be particularly effective (cf., Askren, 1975).

6. Task analysis data are an explicit output of the APM.

7. Training requirements analysis is an explicit output and strength of the APM.

8. Identification of skill levels is a specific output of the APM.

9. Life-cycle costing is not, at present, an identified process or output for APM.

Valuable outputs from the APM which are not included in these questions (and which should be) include logistic support analysis and specific test and evaluation criteria.

No current model, method, or procedure satisfies all of the development tasks and data that are needed for system design and development. At present, the APM is strongest in system, task, training and measurement definition but appears to be weak in responding to manpower and cost questions associated with new systems.

D. Training System Development

The past 30 years have seen the most remarkable advances in training technology in the entire history of human learning. Part of this is due to

applications of computer technology, part to empirical facts about optimal human learning, and much to systematic methods of analyzing and developing training systems. In a broad sense, the last can be termed the "Systems Approach to Training" or "Instructional System Development" (O'Neil, 1979; Vineberg and Joyner, 1980). Instructional system development (ISD) methodologies are in use throughout all military services, and are widely used in non-military education and training. Unfortunately, several current problems are apparent with the ISD technique:

- There is a variety of methods for generating training systems called by the loose generic label of ISD;

- There is no guarantee that any of the ISD methods obtain maximum system performance efficiency or training efficiency; and

- ISD applications frequently come too late in the system development cycle where potential major training problems could be identified before design freeze and corrected through job and task redesign.

To date, the major applications of the APM have been on training systems development. This is, in effect, a test of how well APM can work to generate training requirements and training system data bases (see Appendices A, B, and C). APM is particularly strong in:

- Performance goals and objectives
- Need/discrepancy analysis
- Identification of job requirements
  - Selection of tasks for training
  - Analysis of tasks
  - Construction of job performance measures
- Development of training objectives and objective hierarchies
- Validation of instruction
- Logistic requirements for training systems

It appears to be less useful in such steps as:

- Methods for evaluating optimum training efficiency
- Formal cost-effectiveness evaluations of training systems

Perhaps another way of stating it is that APM is currently emphasizing the "What?" (Objectives) and "Why?" (Functional Purposes) of new training systems rather than the "How?" (Characteristics). For the latter, additional development is needed. There is, however, nothing inherent in the APM concept that would preclude its addressing the "how" of new training systems. Indeed, the APM is so structured that the "how" would be a natural output.

It would appear that the major strength of the APM at present is with respect to front-end analysis of training systems. As noted above, training system analysis has usually come very late in the system development cycle, and there is much concern that these analyses be conducted as a part of the system development process (cf., Seidel and Wagner, 1979). APM seems particularly potentially useful in the initial steps of mission, function, task, and job analysis.

Another similar system under development at this time is the Early Training Estimation System (ETES) which will attempt "... to deal with two major deficiencies in existing technologies: (1) the lack of a systematic tool for describing, storing, and updating system concepts and for transmitting this information to all of the various participants in the development/acquisition process, and (2) the lack of a comprehensive set of training analysis tools which are appropriate for the early phases of design." (O'Brien, 1982). ETES has three major functional components: System Description Technology, Training Estimation Aids and Procedures, and Evaluative Technology. It appears to be particularly strong in comparative evaluation of instructional methods and media and cost-effectiveness evaluation. These are areas in which APM has not moved into heavily. Note should be made of the fact that ETES is under development for computer application with a microprocessor.

The APM and the ETES appear to be complementary. ETES can be of particular value to APM in comparative evaluations of media and instructional methods. APM appears to have a sounder approach to the generation of system and subsystem objectives and development of performance measurement. Both systems appear to generate the kinds of support data for early training projections as described by Jorgensen (1981).

E. Behavioral Simulation Models

For almost 30 years there has been a continuing attempt to develop quantitative simulation models for behavioral, social, and systems processes (cf., Siegel and Wolf, 1969; Pew, Baron, Feehrer, and Miller, 1977; Rouse, 1980). Initial theoretical attempts concentrated on human tracking performance, and have now expanded to encompass decision making and information processing at both direct control and monitoring levels. The question might be asked: What relevance do these models have to APM?

The primary emphasis of these models has been a better understanding and description of human behavior often (but not always) in a system context. For the systems context and tasks for which they are appropriate, these models have sometimes provided very specific quantitative predictions of human behavior. This has normally concerned specific operator and maintenance tasks with little concern for manpower and/or training implications. They are normally time-varying, stochastic models with much concern about task performance and often human performance optimization.

As Siegel, Wolf, and Ozkaptan (1981) have pointed out, early in the system development cycle it may be wise to use qualitative and deterministic methods before switching to complex, computer-based, behavioral simulations. If that is true, APM would in general be the method of choice early in design. APM could then subsequently provide performance parameters, tasks, and measures for time-varying, scenario-driven, stochastic simulation models. In short, APM would describe the objectives, structure, and measures of the system for computer simulation of the system.

F. Logistic Support Analyses

Perhaps even to a greater extent than training, logistic support analyses have traditionally been executed well into the system development cycle and usually after design freeze. It is now apparent that this can no longer be the case; early estimates of logistic requirements are essential since they may determine whether or not a system is operationally feasible. The goal, as Weddle (1981) puts it is "... to build supportability into a system rather than inefficiently bolting it on after the system is deployed."

There are a very large number of logistic support analyses models, two of which may exemplify their structure and purpose:

1. Kyle and Markisohn (1974) have described an Integrated Facilities Requirements System for pilot training. It contained five principal modules:

   - Logistic support requirements for calculating total manpower, aircraft and fuel requirements for training;

   - Base loading for assignment of students and resources for each phase of training;

   - Facilities requirements for estimating specific permanent facilities for the total pilot training program at each base;

   - Efficiency/deficiency estimates to evaluate the training input load with facilities; and

   - Total systems cost which attempts to predict the total cost of all resources required, including investment costs and operations and maintenance costs.

With the exception of cost data, the APM is designed to supply these types of logistics data (see specifically Appendices B and C).

2. While all services have developed extensive logistic support analyses models, the Air Force has particularly pioneered the inclusion of the human resources element in logistics (cf., King and Askren, 1980). They have developed and tested a coordinated human resources technology (CHRT) method for logistics analyses combining: maintenance manpower modeling, job guide development, instructional system development, system ownership costing, and human resources in design trade-offs. Most important is an associated requirement for a unified data base to support logistic analyses in these areas. APM stresses, to a greater degree than CHRT and its derivative Navy system, Hardman, system and task performance objectives and performance measurement.

G. Test and Evaluation

Very early in the introduction of human resources work in system development stress was placed on adequate test and evaluation, particularly of

the human element in systems (cf., Meister and Rabideau, 1965). APM continues this tradition with a strong and explicit module for test and evaluation. Although there has been a considerable literature and practice developed, little standardization has been achieved for human resources test and evaluation either in developmental or operational testing. Major techniques have been developed, including the HEDGE system for the Army's Human Engineering Laboratory and the HFTEMAN (Human Factors Test and Evaluation Manual) for the Navy.

A major Army test and evaluation system has been the Human Resources Test and Evaluation System (HRTES) principally developed for operational testing (cf., Kaplan and Crooks, 1980). HRTES assumes a prototype operational system ready for operational test and evaluation. A test plan is generated by HRTES, performance measures obtained, and the performance evaluated by an application of multi-attribute utility theory. A principal feature is the diagnosis and evaluation of unsuccessful performance. In short, when did an error occur; why did it happen; and what should be done about it?

In contrast, APM is directed toward developing systems where specific system parameters are evolving in system design, places particular emphasis on system goals and objectives, but at the same time assigns particular measures to system parameters and objectives. These data, if generated, would be particularly pertinent as critical inputs to the HRTES. APM would provide a system analysis framework for the HRTES evaluation. HRTES, then, extends APM into the domain of operational testing but, at the same time, APM provides a measurement framework for the HRTES technique.

H. Summary

APM is a static, deterministic model principally useful for early system development and for front-end analysis of human resources elements of military systems. It is specifically valuable in deriving system, subsystem, and human performance objectives in a manner consistent with standard system engineering methods as well as the goals of MIL-H-46855B. No other available models have this capability. Outputs of the APM may be used within other model frameworks for:

- Stochastic, time-varying, scenario-driven simulations
- Training system development
- Logistic support analyses
- Human resources test and evaluation

It is, therefore, complementary to other models in these areas. Perhaps its major weakness as a model is a lack of costing data which might be essential for early evaluation decisions. In its computerized version it allows for quick development and assessment of initial system goals, processes, and products before actual system hardware and software have been selected.

V. RECOMMENDATIONS FOR FURTHER DEVELOPMENT AND APPLICATIONS

As noted earlier, the ultimate objective of this APM development work is to provide users with a uniform, thorough, adaptive and efficient procedure to aid in the process of deriving the most meaningful design specification requirements, design specifications, evaluation measurement requirements or evaluation measures for any planned or existing human-machine system (particularly a training system). The users of the APM for design and measurement purposes are expected to be at: the U.S. Army Infantry School (USAIS); other schools of the U.S. Army Training and Doctrine Command (TRADOC); the Directorate of Training Development (DTD); the Directorate of Evaluation (DOE); and the Directorate of Combat Development (DCD). APM users are also foreseen to include personnel with the U.S. Army Test Boards, as well as the U.S. Army Operational Test and Evaluation Agency (USAOTEA) and, of course, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI). Among the individuals at those agencies who are seen as the ultimate users of automated APM are training developers and evaluators, TRADOC system managers (TSMs), system researchers and designers, analysts and planners. The APM project has supplied the following products to help these users perform their work:

- An initial analytic process model for systems design and measurement.
- A generalizable taxonomy of measurable attributes for the surveillance function found in many manned systems.
- A generalizable model of training systems and their component subsystems.
- Generalizable taxonomies for the Design (curriculum development), Enabling (trainer preparation) and Delivery (instruction) subsystems of training systems.
- A sample application of the model for deriving effectiveness measures for Learner Testing Specifications within the emerging BIFVTS, including a generalizable taxonomy and application procedures.
- A preliminary review of concepts for applying the APM in establishing design requirements.
- An untested procedural outline and demonstration package of a computer-aided APM for deriving training systems measures (using an Apple II Plus computer).
- An annotated bibliography of the manned systems measurement literature (244 documents cited and abstracted).

This list represents considerable progress in an area that has been so difficult to standardize for so many years. The model development is just now

beginning to yield the kinds of guidelines and sample applications that soon will allow it to be learned and applied by those who are its potential users. To help bring the APM development process to the point of application by the ultimate users, several tasks need to be carried out. These are listed in Figure 30. It is noted that the items are not necessarily independent of each other, but some tasks can be seen as being a part of others. They are listed separately, however, because they are identifiably distinct or limited in their purpose. For convenience, the tasks are divided into four groups, according to their primary concerns: data base development, procedures development, applications and application aids, and administrative items development.

A. Data Base Development

1. Develop Performance Items, Attributes, Measures and Specification Requirements for the Remaining Training Subsystems (Command, Logistics and Emplacement)

Currently, generalized taxa for any design, enabling and delivery subsystem have been developed, though their measures and specification requirements remain in need of completion. Taxa for the additional generalized training subsystems also should be developed. Their applicability to BIFVTS or other issues could be verified through some real world comparison or evaluation, by subject-matter experts (SMEs) or otherwise. The same procedures should be applied as used in prior taxa development.

2. Develop Data Bases for Other Than Training Systems

This task is intended to make the APM useful for analyzing human-machine systems in addition to those in the training system class. Depending upon the active work areas of the using agency, generalized taxonomies of performance items, attributes, measures and specification requirements could be developed for such system classes as weapons, communication, navigation, search and surveillance, target acquisition and fire control, command and control, intelligence, electronic warfare or any other type.

This task should identify the many (sometimes subtle) roles of human operators in the total system measurement and evaluation process. It should clarify the contribution and influence of operators in the various system attributes selected for specification or measurement.

3. Identify the Sub-Taxonomies for Generally Stated Analytic Purposes

This task is intended to provide the user with computer-aided recommendations of appropriate performance items for certain stated purposes of measurement or specification. It consists of a mapping process in which subsets of performance items are identified for each generally stated analytic purpose. The APM would then present the user with those recommendations, if his purpose were one of those in storage, thus easing the user's task of generating a completely new subset of purpose-relevant performance items. The user would then proceed by editing the recommended subset to suit his needs. For reasons of efficiency, this task should be carried out together with Task 8.

A. Data Base Development

1. Develop performance items, attributes, measures and specification requirements for the remaining training subsystems (command, logistics and emplacement)
2. Develop data bases for other than training systems
3. Identify the sub-taxonomies for generally stated analytic purposes

B. Procedures Development

4. Further develop procedures for APM application to measures derivation
5. Further develop procedures for APM application to system design specification
6. Develop procedures for differentiating specifications and measures in terms of weighting factors, delay tolerance and criticality
7. Modify procedures and programs for use with a computer large enough to provide the user assistance, data base and processing capacity, and speed consistent with the expanded capabilities
8. Improve procedures for specifying new analytic purposes

C. Applications and Application Aids

9. Train users to apply the APM
10. Apply the APM to the measurement of an existing Army system
11. Apply the APM to the specification of a new Army system
12. Provide the user with a computer-generated assessment of each analysis
13. Develop computer-assisted instructions (CAI) for users of the APM

D. Administrative Items Development

14. Incorporate on-line security and accounting procedures
15. Provide mechanisms for future modification of the APM

Figure 30. Recommended Further Research on the APM

B. Procedures Development

4. Further Develop Procedures for APM Application to Measures Derivation

One of the most difficult-to-routinize segments of the APM is that in which measurable attributes are determined and actual measures are selected. Some progress has been made during this project in beginning to identify specific procedures for measures derivation. More needs to be done, however, especially if computer-aiding is to be used for this segment. In particular, the analytic steps leading to measures derivation involve a determination of issues that imply a need to measure particular attributes. The research method should include model application with several existing or developing training systems to verify or modify its component parts, its adequacy, and its practicality. The effort should also produce improved and amplified procedures and guidelines for using the model.

Additional work is needed to incorporate the measures of effectiveness and performance (MOE-MOP) development steps into the APM, identify the relationships among MOE-MOP for systems-subsystems levels, and identify the relationships among the machine and human components in terms of contribution to MOE-MOP development or specification. This subtask can build on the current BIFVTS work, by continuing more sample or partial applications to increasingly complex issues of military training, both to verify and to improve the procedural guidelines. This process is analogous to the earlier one of generating taxonomization guidelines. The procedural guidelines would allow for the derivation of MOE-MOP specific to given measurement purposes and provide for direct MOE-MOP (type) selection given the defined measurement purpose. Those guidelines, when better understood, will define the algorithm for measures derivation that then can be used to improve the computer-aided process.

5. Further Develop Procedures for APM Application to System Design Specification

The purpose of this research item is analogous to that of Item 4, but as applied to the APM for specification. Sample applications should involve the specification of several new Army systems. All component parts of the specification model should be addressed; concepts and definitions should be clarified and application guidelines should be developed. In addition, the utility of the model for assessing independently generated design requirements should be evaluated.

6. Develop Procedures for Differentiating Specifications and Measures in Terms of Weighting Factors, Delay Tolerance and Criticality

The practical aspects of model utilization suggest that there will be times when the full range of performance taxa, attributes, specifications or measures cannot be applied in its entirety, and that choices will have to be made to select only the most important ones for application. To aid the user

in selecting those taxa, attributes, specifications or measures which are most important, a procedure should be developed which helps to rate or rank those items in accordance with such criteria as: criticality to mission performance, amenability to alternatives or corrective actions, tolerance to postponement or delay in application, or other criteria to be determined.

7. Modify Procedures and Programs for Use with a Computer Large Enough to Provide the User Assistance, Data Base and Processing Capacity, and Speed Consistent with the Expanded Capabilities

This task is intended to produce a practical and useful tool by building upon the existing computer-aided demonstration capability. It can be accomplished by adding flexibility, instruction options, thoroughness, and data bases to the rudimentary computer-based model. It should also include a test of the procedures by a skilled, but APM-naive, analyst to determine where modifications are required to clarify, simplify or otherwise improve their value and ease of use.

8. Improve Procedures for Specifying New Analytic Purposes

This task can build upon the experience gained in conducting Task 3. It consists of analyzing and documenting the process by which analytic purposes are specified and how they subsequently influence the model's application (as in Task 3). It is intended that the procedures developed be incorporated in the computer-aided model, to assist users at the appropriate stage of application.

C. Applications and Application Aids

9. Train Users to Apply the APM

This task is one in which the previously developed APM procedures are placed into operation with some potential users. One possible agency to aid in this dissemination function is the U.S. Army Training and Doctrine Command (TRADOC). Administrative contacts, explorations and information exchange with possible interested agencies should begin well in advance of the potential application efforts. The results of these trials should be used to support Task 13 in the development of CAI resources.

10. Apply the APM to the Measurement of an Existing Army System

This task involves extending the preliminary BIFVTS applications of the APM to a different measurement purpose that also can serve as a validation or verification exercise. For example, the model can be applied in the context of the Training Effectiveness Analysis (TEA) of the BIFVTS which was planned by USAIS/USAIC to begin in the 4th Qtr FY 1982. Current developments can be extended to the point where derivation of specific measure sets for the effectiveness of the BIFVTS subsystem can be generated. These measure sets can then be examined for feasibility, validity and utility in the context of the TEA. It would be necessary to review the measurement issues to be addressed in the TEA that are relevant to the BIFVTS curriculum, and one or more of those issues should be selected as the basis for this task. The performance taxa pertaining to each selected issue and the measurement derivation

guidelines should be used to generate a measures hierarchy for each selected issue. Differences between APM and TEA measures should be examined so that reasons can be determined for those differences. Commonalities should also be noted and their reasons understood. For practical reasons, this in-depth application and comparison should focus on a narrow aspect of the BIFVTS, such as Basic Gunnery Learner Testing. This task would also provide an opportunity to focus on human operator contributions to performance, such as motivation, attitudes, capabilities, and procedures under given environmental, administrative and other constraints.

11. <u>Apply the APM to the Specification of a New Army System</u>

Initial extension of the APM to the specification of system design requirements was begun during the latter portion of this contract. This follow-up task should extend and further explore the use of the APM as a tool, through application to a new (or developing) system. A training system is recommended as one possibility. The purpose is to improve and to verify, to the extent possible, the capability of the APM to serve this function. This can be done through the "blind" development of training system design specifications for a new or developing system to be selected by an interested Army office. A comparative assessment can be carried out between design specifications as developed by using the APM, and similar specifications as developed by other methods, such as the Early Training Estimation System under development by the ARI Fort Bliss Field Unit. This task could also make use of the APM's capabilities both to generate new design specifications and to aid in the diagnostic assessment of previously generated design specifications. For the same practical reasons as mentioned under Task 9, this comparative application should take place in depth over a narrow aspect of the new training system.

12. <u>Provide the User with a Computer-Generated Assessment of Each Analysis</u>

This is a relatively small task which will provide the user with feedback on how each analysis was carried out. It will provide assessments in terms of thoroughness or breadth of the analysis, conformance with or departures from computer recommendations, completeness or lack of same in associating performance items with final measures or specifications, and other criteria by which the computer can report on the user's activities. It is intended that these assessments will prompt the user to make changes or improvements where necessary or to obtain some measure of assurance that the analysis was probably conducted in a satisfactory manner.

13. <u>Develop Computer-Assisted Instructions (CAI) for Users of the APM</u>

This task would provide the computer-based package with a built-in training capability, using the self-pacing techniques of computer-assisted instructions (CAI). Completion of this task should follow whatever remaining development effort is necessary to yield routinized (computer-aided) procedures for application by users. It should also follow application tests of those procedures by user personnel (see Task 9). This task can make use of any handbooks, guidelines, workshops or other items that were previously

developed to train or assist users. The task should also consider the training/usage of the APM process by various personnel types and for both possible purposes (evaluation and specification of human-machine systems). CAI can insure that procedures for training users of the APM are as programmatic, proceduralized, routinized and simplified as possible. Field tests of these CAI procedures should aim to confirm their completeness and accuracy, their utility (based on the acceptance by users) and their validity (based on the quality and comprehensiveness of products).

D. Administrative Items Development

14. Incorporate On-Line Security and Accounting Procedures

This task is designed to protect the integrity of the model and its data bases, once it becomes accessible to a wide variety of users. It requires the incorporation of appropriate access codes in order to modify data bases or programs. It also provides for a record of usage by amount, type, user description and other accounting-type information that can serve to describe how the APM is being used, and to suggest how additional developmental resources can be best applied.

15. Provide Mechanisms for Future Modification of the APM

To help the computer-aided instruction system in carrying out its functions of information exchange and documentation for users, a technical capability should be established for maintaining the APM, its associated data bases, and its various application routines and records. Users can then be helped with the latest fund of knowledge, techniques and experience. A current directory of users would allow for rapid distribution of application documents, program modifications, information requests, and suggestions to improve the value of this resource to users.

One of the most important sources of ideas to enhance the APM's utility and value is the user population itself. A method should be established for permitting and, in fact, encouraging users to supply feedback of application ideas to the central APM technical office, with the assurance that those ideas will be given careful consideration and dissemination in the most appropriate manner. Dissemination can employ a newsletter, a "new application" description, a revised data base or even a message for CRT display when users log on to use the model. In fact, one way in which users can conveniently communicate briefly with the APM central office could be via the interactive terminal, such as by typing in messages or inquiries after using the program or by pausing during use when a problem is encountered. The specific mechanisms for keeping the APM current and useful should be determined and implemented in this task item.

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VII. ANNOTATED GLOSSARY OF ANALYTIC PROCESS MODEL TERMS AND CONCEPTS

Numerous concepts, procedures, techniques and data bases are presented in this report. Of necessity, these are expressed in technical terminology, much of which is specific to training applications. Understanding and application of these concepts, data bases, etc., requires understanding of the terminology. This glossary defines and clarifies the terms used, in an attempt to foster that understanding.

The definitions and clarifications presented herein are drawn principally from the following sources:

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GLOSSARY

ACHIEVEMENT.

See: LEARNING ACHIEVEMENT

ACTION VERB. The action verb is the behavior indicator of a performance objective.

In a statement of a performance objective, the action verb discloses the observable behavior that the learner is required to manifest.

See also: PERFORMANCE OBJECTIVE
CAPABILITY VERB

ADULT LEARNING CLIMATE. The adult learning climate is that set of environmental, procedural, and interpersonal features that, typically, facilitates learning by adults.

Features of the adult learning climate:

1. Learners are treated with respect.
2. Learners participate in the learning planning process, helping to translate diagnosed needs into specific performance objectives and learning activities.
3. Learners participate in the diagnosis of their own needs.
4. Learners' comments, questions, discussions are encouraged and welcome.
5. Learners share in conducting learning experiences.
6. Learners have opportunities for self-evaluation.
7. Emphasis is placed on the practical applications of the learning.
8. Experiential techniques are used to the fullest possible extent (e.g., group discussion, simulations, case studies, role-playing, etc.)

Synonym: ADULT LEARNING ENVIRONMENT

See also: EXTERNAL CONDITIONS OF LEARNING
INDIVIDUALIZED INSTRUCTION

ANALYSIS. The first phase of instructional system development.

Comprises the early stages of curriculum design, such as the analysis of needs, goals and objectives, and the organization of course units.

Entails procedures for defining the job to be trained; dividing the job down into statements of tasks; and selecting the tasks to be trained.

Further extends to constructing job performance measures for tasks selected for training, and to deciding whether the tasks should be trained in schools, on the job, or elsewhere.

Synonym: FRONT END ANALYSIS

See also: TRAINING NEEDS ASSESSMENT
JOB ANALYSIS

ANALYSIS OF EXISTING COURSES. In instructional system development, analysis of existing courses is undertaken to avoid needless duplication of effort, by permitting existing courseware to be adapted to new training needs.

Factors to consider in the analysis of existing courses:

1. The acceptability of the job analysis on which the existing course was based.
2. The appropriateness of the criteria that were used to select tasks to be trained through the existing course.
3. The validity of the job performance measures used in the existing course.
4. Validation of the existing course.

ANALYSIS OF PERFORMANCE OBJECTIVES.

See: TASK ANALYSIS

ANALYTIC PROCESS MODEL. The Analytic Process Model is a conceptual framework for systematizing the design and evaluation of human-machine systems.

Stages of the Analytic Process Model:

1. Establish the Design/Evaluation context by identifying the system's work requirements. (This is the Systems Taxonomy Model stage.)

2. Establish the focus of the Design/Evaluation in terms of necessary system attributes.

3. Implement the application details to Design/Evaluate the attributes.

4. Interpret the outcome of the Design/Evaluation, and develop conclusions and recommendations.

Synonym: APM

See also: SYSTEMS TAXONOMY MODEL
DESIGN
EVALUATION

APM.

See: ANALYTIC PROCESS MODEL

ASPECTS OF PERFORMANCE. The aspects of human-machine system performance form one dimension for organizing the system's work requirements. The aspects of performance address the work itself and the circumstances under which the work is required.

The aspects of performance include five mutually exclusive categories:

1. Performance Potentialities
   (inherent capabilities)

2. Performance Processes
   (activities, methods, techniques)

3. Performance Products
   (goods, services, other deliverables)

4. Performance Environment
   (natural impediments to the work)

5. Performance Constraints
   (man-made, artificial impediments)

The aspects of performance form one dimension of the Systems Taxonomy Model. They interact with another dimension, viz., levels of system description, to form fifteen cells or sub-taxonomies within which any system's work requirements can be exhaustively identified and organized.

See also: SYSTEMS TAXONOMY MODEL
LEVELS OF SYSTEM DESCRIPTION
PERFORMANCE POTENTIALITIES
PERFORMANCE PROCESSES
PERFORMANCE PRODUCTS
PERFORMANCE ENVIRONMENT
PERFORMANCE CONSTRAINTS

ATTITUDINAL DOMAIN OBJECTIVES. Performance objectives belonging to the attitudinal domain require that the learner demonstrate that he or she chooses some prescribed course of personal action, or behaves in accordance with a prescribed set of values.

See also: PERFORMANCE OBJECTIVES
LEARNING DOMAIN TAXONOMY MODELS
INFORMATION DOMAIN OBJECTIVES
MENTAL SKILLS DOMAIN OBJECTIVES
PHYSICAL SKILLS DOMAIN OBJECTIVES

ATTRIBUTE. An attribute of a human-machine system is a concrete, observable feature of the system that bears directly on the work that the system can and does perform.

Attributes are linked to specific taxa of performance. For each performance taxon, there exists a set of system attributes that collectively determine whether the system satisfies that taxon.

A system attribute is something that a system designer can and must control, through design decisions, to insure that the system will satisfy the performance taxon to which the attribute is linked. An attribute also is something that an evaluator can and must measure to determine whether the performance taxon is met.

See also: TAXON
MEASURE
DESIGN SPECIFICATION

BEHAVIORAL OBJECTIVE.

See: PERFORMANCE OBJECTIVE

CAPABILITY VERB. The capability verb of a performance objective statement indicates the particular domain of learning to which the objective belongs.

See also: PERFORMANCE OBJECTIVE
DOMAINS OF LEARNING
ACTION VERB

CHARACTERISTICS-LEVEL TAXA. Characteristics-level taxa are statements of how a specific purpose behind a system's work is required to be achieved. Characteristics-level taxa define the particular ingredients, methods and milestones that the system is to include in its work in order to satisfy its reasons for working.

A Characteristics-level taxon is linked to or descends from a particular Functional Purposes-level taxon. The Characteristics-level taxon defines a detailed capability ingredient, or procedural step, or intermediate output necessary to achieve a particular purpose behind some basic potentiality, process or product. Characteristics-level taxa also include definitions of the relevant environmental and constraining factors that may interfere with the system's ability to provide these capability ingredients, carry out these procedural steps, or deliver these intermediate outputs.

Characteristics-level taxa consist of the system's performance potentialities. processes, products, environment and constraints viewed at the bottom-most level of system description. It is a view of work requirements as things that are to be achieved in certain ways.

See also: TAXON
OBJECTIVES-LEVEL TAXA
FUNCTIONAL PURPOSES-LEVEL TAXA
LEVELS OF SYSTEM DESCRIPTION
ASPECTS OF PERFORMANCE

COGNITIVE STRATEGIES. A learner's cognitive strategies are the internally organized mental skills by means of which the learner exercises control over his or her own processes of attending, learning, remembering, and thinking.

See also: LEARNING DOMAIN TAXONOMY MODELS
INTERNAL CONDITIONS OF LEARNING

COLLATERAL SYSTEM. A collateral system of a particular human-machine system of interest is, itself, a human-machine system that interacts directly with the system of interest so that it affects the work required of the system of interest.

A collateral system may work either cooperatively or in competition with the system of interest.

Collateral systems are members of the system hierarchy of the system of interest.

See also: HUMAN-MACHINE SYSTEM
SYSTEM HIERARCHY

COMMAND SUBSYSTEM. The Command Subsystem is one of the six generic, functionally oriented subsystems of any training system. Command provides administrative control over the training system by assessing training needs; allocating resources; recruiting training system personnel; and monitoring, evaluating and recording learner and system performance.

Command contributes to the learning-helping function by constructing and managing the system in which the learning activities can take place.

The principal operator or staff member of the Command Subsystem is the training administrator.

See also: TRAINING SYSTEM
LEARNING
LEARNING-HELPING

CONDITIONS OF LEARNING. The conditions of learning are those features or qualities of the training system, including the personnel, equipment and procedures, that affect how well a particular learner learns.

See also: INTERNAL CONDITIONS OF LEARNING
EXTERNAL CONDITIONS OF LEARNING

CRITERION-REFERENCED TEST.

See: OBJECTIVE-REFERENCED TEST

CUE. A cue is a subtle or indirect form of guidance, given to help a learner recall and apply some particular fact, procedure, word, phrase, etc., without actually supplying the fact, procedure, etc.

See also: GENERAL LEARNING GUIDELINES
PROMPTING

DECISION FLOW CHARTING. Decision flow charting is a procedure for identifying and assessing the decisions required in a task, by means of reduction to a series of binary choices.

See also: INFORMATION PROCESSING ANALYSIS
DECISION LEVEL ANALYSIS

DECISION LEVEL ANALYSIS. Decision level analysis is applied to the decisions required in a task to establish a rating of the time, complexity and nature of each decision.

See also: INFORMATION PROCESSING ANALYSIS
DECISION FLOW CHARTING

DELIVERY SUBSYSTEM. The Delivery Subsystem is one of the six generic, functionally oriented subsystems of any training system. Delivery is the most important training subsystem, in that the primary training function (learning) takes place there. In the Delivery Subsystem, the prescribed sensory learning activities are carried out and the learner achieves the intended behavioral effects.

The principal operator of the Delivery Subsystem is the learner. The learner is assisted in Delivery by all other training system personnel, who play various learning-helping roles.

See also: TRAINING SYSTEM
LEARNER
LEARNING
LEARNING-HELPING

DEPENDENT OBJECTIVE. One performance or enabling objective is dependent upon another if it cannot be achieved unless the other first is achieved.

If one objective is dependent upon another, it must be pursued <u>after</u> the other, during training.

See also: INDEPENDENT OBJECTIVES
SUPPORTIVE OBJECTIVES
PERFORMANCE OBJECTIVE
SEQUENCING OBJECTIVES

DESIGN. Usage No. 1 (Principal Definition): One of two applications of the Analytic Process Model. Design of a human-machine system is the process of selecting and securing all of the attributes that the system must possess in order to satisfy its work requirements.

Usage No. 2 (Secondary Definition): One of six generic subsystems of any training system.

<u>Synonym</u>: DESIGN SUBSYSTEM

See also: ANALYTIC PROCESS MODEL
ATTRIBUTE
DESIGN SPECIFICATION
EVALUATION

DESIGN SPECIFICATION. A design specification is a plan for insuring that a system will have some particular required attribute.

A design specification describes how the system will be built, maintained and operated so that a specific attribute needed to satisfy a particular performance requirement or taxon will be present.

See also: ATTRIBUTE
TAXON
MEASURE

DESIGN SUBSYSTEM. The Design Subsystem is one of the six generic, functionally oriented subsystems of any training system. Design carries out the development of the curriculum/program of instruction. In so doing, Design plans the instructional events, selects training technology, assembles content material, and defines facilitator and learner requirements.

The Design Subsystem is the portion of the training system in which the Instructional System Development (ISD) model is applied.

Design Subsystem contributes to the learning-helping function by identifying the specific behavioral effects needed by the learners and by planning the sensory activities that will lead to those effects.

The principal operator of the Design Subsystem is the curriculum developer.

See also: TRAINING SYSTEM
INSTRUCTIONAL SYSTEM DESIGN
LEARNING
LEARNING-HELPING

DEVELOPMENT OF OBJECTIVES. Development of objectives is the process by which performance objectives, enabling objectives and prerequisites for training are identified.

Steps in the development of objectives:

1. Identify performance objectives by translating job performance measures into training-oriented terms.

2. Analyze the performance objectives (tasks) to identify constituent prerequisite or supportive achievements.

3. Continue the analysis until a level of prerequisites is reached which all learners have achieved.

Product of the development of objectives:

A list of performance objectives and prerequisites analyzed to the level where it can be assumed that the individuals to be trained are prepared to begin.

See also: TASK ANALYSIS
PERFORMANCE OBJECTIVE
ENABLING OBJECTIVE
ESSENTIAL PREREQUISITE
SUPPORTIVE PREREQUISITE

DOMAINS OF LEARNING. The domains of learning are categories into which performance objectives, enabling objectives, and prerequisites may be grouped, in accordance with whether the prescribed action/behavior is mental, physical, or attitudinal.

See also: LEARNING DOMAIN TAXONOMY MODELS

EMPLACEMENT SUBSYSTEM. The Emplacement Subsystem is one of the six generic, functionally oriented subsystems of any training system. Emplacement takes the plans developed by Design Subsystem and constructs, acquires or assembles all materials, equipment, installations, supplies, etc., needed to implement those plans.

Emplacement contributes to the learning-helping function by providing the tools needed to carry out the sensory learning activities.

The principal operator of the Emplacement Subsystem is the facilities developer.

See also: TRAINING SYSTEM
DESIGN SUBSYSTEM
LEARNING
LEARNING-HELPING

ENABLING OBJECTIVE. An enabling objective is a learned capability that facilitates the learning of a larger performance objective. An enabling objective can be conceived as an intermediate achievement, or milestone, that must be or can be accomplished to progress toward the final achievement represented by the performance objective.

See also: PERFORMANCE OBJECTIVE
ESSENTIAL PREREQUISITE
SUPPORTIVE PREREQUISITE
LEVELS OF OBJECTIVES
LESSON PLAN

ENABLING SUBSYSTEM. The Enabling Subsystem is one of the six generic, functionally oriented subsystems of any training system. Enabling is, itself, a self-contained training system: it carries out learning and learning-helping activities to enable facilitators to (1) become familiar with the plans, training content, equipment and facilities provided by the Design and Emplacement Subsystems; (2) become qualified and prepared to teach the curriculum effectively; and (3) tailor the curriculum to the specific needs of a particular class or team of learners.

Within the total training system, Enabling contributes to the learning-helping function by providing personnel qualified to assist the learners directly by presenting information, demonstrating techniques, coaching learners' efforts, evaluating learners' performance, and correcting learners' deficiencies. Enabling also contributes to learning-helping by fine-tuning a general program of instruction to specific learning needs of specific learners.

The principal operator of the Enabling Subsystem is the facilitator.

Common synonyms for Enabling Subsystem are "Instructor Preparation" and "Training-the-Trainer."

See also: TRAINING SYSTEM
DESIGN SUBSYSTEM
EMPLACEMENT SUBSYSTEM
FACILITATOR
LEARNING
LEARNING-HELPING

ENTRY TEST. An entry test is a test of a prerequisite for training.

Entry tests provide a basis for accepting or rejecting candidate learners, and for determining whether particular learners require remedial training.

See also: OBJECTIVE-REFERENCED TEST
PRETEST
POSTTEST

ERROR DATA. Error data consist of item analyses of pilot test learners' test responses. The analyses disclose achievement failures, which in turn point to needed improvements in the instruction.

See also: FEEDBACK

ESSENTIAL PREREQUISITE. An essential prerequisite for a particular performance objective or enabling objective is a performance capability that actually is incorporated within the objective in question.

The objective cannot be achieved unless the essential prerequisite is satisfied.

See also: PERFORMANCE OBJECTIVE
ENABLING OBJECTIVE
DEPENDENT OBJECTIVE
DEVELOPMENT OF OBJECTIVES
SUPPORTIVE PREREQUISITE

EVALUATION. Evaluation is one of two applications of the Analytic Process Model. Evaluation of a human-machine system is the process of determining whether the system satisfies all of its work requirements.

Synonym: MEASUREMENT

See also: ANALYTIC PROCESS MODEL
MEASURE
DESIGN

EXTERNAL CONDITIONS OF LEARNING. A learner's external conditions of learning for a particular performance or enabling objective are those features or qualities supplied by the facilitator, the learning materials and media, the facilities, etc., that affect the particular learner's ability to achieve the particular objective.

See also: TACTICS OF INSTRUCTION
INSTRUCTIONAL FEATURES
CONDITIONS OF LEARNING
INTERNAL CONDITIONS OF LEARNING
ADULT LEARNING CLIMATE

FACILITATOR. A facilitator is a key learning-helper in a training system, and is the principal operator of the training Enabling Subsystem.

The facilitator interacts directly with the learner to aid the learner in carrying out planned sensory activities to achieve desired behavioral effects.

Common synonyms for "facilitator" include "teacher," "instructor," and "trainer."

See also: LEARNING-HELPING
TRAINING SYSTEM
ENABLING SUBSYSTEM
DELIVERY SUBSYSTEM
LEARNER

FEEDBACK. In course design, feedback is the process of gathering information from learners as the basis for improving the training.

See also: FORMATIVE EVALUATION
PILOT TESTING
ERROR DATA

FIELD TRIAL.

See: PILOT TESTING

FORMATIVE EVALUATION. Formative evaluation is the tryout and revision of a training system prior to its full-scale operational delivery. Formative evaluation entails delivery of the instruction to representatives of the intended learner population, collection of useful data from those representatives, analysis and interpretation of those data, and revision of the instruction based upon the findings.

The word "formative" implies that the evaluation occurs while the instructional program is still in development. Formative evaluation provides an opportunity to correct mistakes made in the instructional design process before the delivery process fully matures.

See also: PILOT TESTING
FEEDBACK
SUMMATIVE EVALUATION

FRONT END ANALYSIS.

See: ANALYSIS

FUNCTIONAL PURPOSES-LEVEL TAXA. Functional Purposes-level taxa are statements of why specific performance is required of a system, without reference to how the requirement is to be achieved.

A Functional Purposes-level taxon is linked to or descends from a particular Objectives-level taxon. The Functional Purposes-level taxon defines a specific reason why the system is expected to possess a particular basic capability, or carry out a basic activity, or deliver a basic output.

Functional Purposes-level taxa also include definitions of the relevant environmental and constraining factors that may impede satisfaction of the reasons behind the system's work requirements.

Functional Purposes-level taxa consist of the system's Performance Potentialities, Processes, Products, Environment and Constraints viewed at the middle level of system description. It is a view of work requirements as things that exist for specific purposes, the achievement of which merits study.

See also: TAXON
OBJECTIVES-LEVEL TAXA
CHARACTERISTICS-LEVEL TAXA
LEVELS OF SYSTEM DESCRIPTION
ASPECTS OF PERFORMANCE

GENERAL LEARNING GUIDELINES. The general learning guidelines consist of four requirements deemed essential for helping learners to learn:

1. Inform the learner of the objective.
2. Provide for active practice by the learner.
3. Provide guidance and prompting to the learner.
4. Provide feedback to the learner concerning his/her performance.

See also: INSTRUCTIONAL EVENTS
PROMPTING
CUE

GOAL. A goal is a statement of what "ought to be" with respect to learners' or job performers' achievements.

In the training context, goals usually are broad statements of the ultimate intended outcomes of educational enterprises.

See also: NEED
NEEDS ASSESSMENT

HUMAN-MACHINE SYSTEM. "Human-machine system" is the general entity of interest to the Analytic Process Model. It is a collection of people, equipment and procedures that work together to accomplish specified functions.

INDEPENDENT OBJECTIVES. Two performance objectives, or two enabling objectives, are independent if the learning/achievement of one of them has no effect on the learning/achievement of the other.

If two objectives are independent, the sequence in which they are pursued during training is irrelevant.

See also: DEPENDENT OBJECTIVE
SUPPORTIVE OBJECTIVES
PERFORMANCE OBJECTIVE
SEQUENCING OBJECTIVES

INDIVIDUALIZED INSTRUCTION. Individualized instruction is a training delivery subsystem that permits:

1. Learners to choose their own individual performance objectives, or

2. Alternative media to be selected by individual learners to pursue objectives, or

3. Learners to progress at their own rates.

Individualized instruction is training in which differences in individuals' needs, learning rates, attention spans, learning styles, levels of competence, etc., are reflected in the learning activities experienced by individual learners. Individualized instruction is a basic requirement for all adult training.

An individualized instructional system should make it possible for individual learners to progress at their own rates of learning and to continue the instructional process until mastery. The instructional system must obtain reliable and timely information on an individual learner's learning progress and make adaptations appropriate to the individual learner.

See also: INTERNAL CONDITIONS OF LEARNING
ADULT LEARNING CLIMATE
LEARNING STYLE

INFORMATION DOMAIN OBJECTIVES. Performance objectives belonging to the information domain require that the learner demonstrate the ability to recall bodies of knowledge.

See also: PERFORMANCE OBJECTIVES
LEARNING DOMAIN TAXONOMY MODELS (cont'd)
MENTAL SKILLS DOMAIN OBJECTIVES
PHYSICAL SKILLS DOMAIN OBJECTIVES
ATTITUDINAL DOMAIN OBJECTIVES

INFORMATION PROCESSING ANALYSIS. A component of Task Analysis, information processing analysis is applied to a performance objective to reveal the sequence of mental operations it requires.

Information processing analysis is premised on the notion that complex human performance can be conceived as composed of simpler parts. The fundamental rule for information processing analysis is: carry the analysis to the point where you are convinced that the revealed operations are simple.

Information processing analysis often is depicted via flowcharting; the flowchart nodes consist of information inputs, mental actions/computations, and decisions.

See also: TASK ANALYSIS
TASK CLASSIFICATION
LEARNING TASK ANALYSIS

INSTRUCTIONAL EVENTS. The instructional events are the distinct steps in a lesson through which the learner, facilitator and material interact to progress toward the lesson objective.

The instructional events include:

1. Gaining learner's attention.
2. Informing learner of the objective.
3. Stimulating recall of prerequisites.
4. Presenting stimulus material.
5. Providing learning guidance.
6. Eliciting the performance.
7. Providing feedback about performance correctness.
8. Assessing the performance.
9. Enhancing retention and transfer.

See also: LESSON PLAN
STRATEGY OF INSTRUCTION
TACTICS OF INSTRUCTION

INSTRUCTIONAL FEATURES. Instructional features are those components of a lesson that are distinct from the instructional content. The instructional features include the statements of performance objectives and enabling objectives, self-tests, practice exercises, discussion topics, etc.

INSTRUCTIONAL SETTING. The instructional setting for a particular task or performance objective is the context, situation or type of environment in which training will take place for that task/objective.

Military training systems typically use one or more of these settings:

1. Job Performance Aid (JPA)
2. Self-Teaching Exportable Package (STEP)
3. Formal On-the-Job Training (FOJT)
4. Installation Support School (ISS)
5. Resident School (RS)

INSTRUCTIONAL SYSTEM DESIGN. Instructional system design is the broad application of the "systems approach" to training. It entails the actual preparation of instruction. It involves determination of how the learners will be managed, the kinds of learning experiences they will have, the activities in which they will engage, and the form and content of the instructional delivery system.

Steps in instructional system design:

1. Determine training needs.
2. Organize the course and the units of instruction.
3. Write performance objectives.
4. Analyze the objectives.
5. Prepare assessments of learner performance.
6. Sequence instruction within each objective.
7. List instructional events for enabling objectives.
8. Select stimulus types.
9. Select instructional media.
10. Select conditions of learning.
11. Write prescriptions/plans.
12. Develop materials.
13. Conduct formative evaluations.
14. Train pilot test facilitators.
15. Conduct pilot test.
16. Make final revisions.
17. Conduct summative evaluations.

Key products of instructional system design:

1. A performance objective corresponding to each task to be trained.
2. Test items to measure each performance objective.
3. Test of entry-level behaviors to validate original assumptions.
4. Sequencing of instruction for all dependent tasks/enabling objectives.

<u>Synonym</u>: INSTRUCTIONAL SYSTEMS DEVELOPMENT

INTERNAL CONDITIONS OF LEARNING. A learner's internal conditions of learning for a particular performance or enabling objective are those features or qualities within the learner, himself or herself, that affect the learner's ability to achieve that objective.

A learner's internal conditions of learning include his or her motivation with respect to the objective of interest, recall of prior learning,

satisfaction of prerequisites, cognitive strategies, and any other tendencies, practices, memories, etc., of that particular learner that affects his or her achievement of that particular objective.

Individual learners' motivation levels may be affected by:

1. The learning content.
2. The information format.
3. The sequencing of instruction.
4. Personal attitudes and values.

Individual learners vary in:

1. The learning sources they prefer and from which they learn best.

2. The learning conditions under which they are most comfortable and effective.

3. Some aspects of information processing style.

4. Other personal abilities and characteristics.

See also: CONDITIONS OF LEARNING
PRESENT CONDITION OF LEARNING
COGNITIVE STRATEGIES
EXTERNAL CONDITIONS OF LEARNING

JOB ANALYSIS. The process of describing all of the performance elements, or tasks, that make up a job.

Entails finding out exactly what job performers do when they do the job, the order in which they do it, and the level of skill or performance deemed adequate for the job.

Job analytic procedures:

1. Initial development of a tentative task list from existing written doctrine, expert panel, analysis of similar jobs, and/or joint effort with developers of a new human-machine system for which the job is required.

2. Authentication of the tentative task list using actual job incumbents.

3. Validation of the task list using other job incumbents.

4. Collection of task conditions; cues that initiate and guide the task performance; and standards representing adequate task performance.

Job analytic products:

1. A validated list of the tasks comprising the job under study.
2. Itemization of the conditions under which each task is performed.
3. Specification of the clues for initiating the tasks.

4. Specification of the standards of performance of the tasks.
5. Listing of the elements of each task.

JOB PERFORMANCE MEASURE. A job performance measure is a test of the adequacy of a job incumbent's work under actual job application conditions. It is an on-the-job assessment of how well the job is done.

A job performance measure must be established for each task that is selected for training. The job performance measure should be the best available indicator of how well the task is performed.

The job performance measure must be validated under field conditions. To be valid, when it is administered to job incumbents, it must distinguish those who can perform the task satisfactorily from those who can't.

Job performance measures form the basis for developing performance objectives.

See also: JOB ANALYSIS
TASK ANALYSIS
PERFORMANCE OBJECTIVE
PREDICTIVE VALIDITY OF TRAINING

LEARNER. A learner is the key operator of a training system, and the principal operator of the training Delivery Subsystem. The learner is the person who carries out and experiences planned sensory activities to achieve intended behavioral effects.

Common synonyms for "learner" include "student" and "trainee."

See also: LEARNING
TRAINING SYSTEM
DELIVERY SUBSYSTEM
FACILITATOR

LEARNING. Learning is any activity involving the senses that affects behavior.

Learning is the principal function of a training system.

In a training system, desired human behavioral effects are achieved through the conduct of planned human sensory activities.

See also: LEARNER
LEARNING-HELPING
TRAINING SYSTEM

LEARNING ACHIEVEMENT. A learner's learning achievement is how well he or she performs specific performance objectives of interest.

Learning achievement is performance evaluated with regard to its adequacy.

Synonym: ACHIEVEMENT

LEARNING DOMAIN TAXONOMY MODELS. Each learning domain taxonomy model consists of a set of categories into which performance objectives, enabling objectives, and prerequisites may be grouped. In each taxonomy model, the categories are mutually exclusive and jointly exhaustive, i.e., every objective and prerequisite belongs to one and only one category of each taxonomy model. In every model, the categories relate in some fashion to mental, physical and attitudinal actions/behaviors.

The three-category taxonomy model (after Bloom, et al.):

1. Cognitive domain.
2. Affective domain.
3. Psychomotor domain.

The four-category taxonomy model (Branson, et al.):

1. Information domain.
2. Mental skills domain.
3. Physical skills domain.
4. Attitudinal domain.

The five-category taxonomy model (Gagne, et al.):

1. Information learning domain.
2. Intellectual skills domain.
3. Cognitive strategies domain.
4. Motor skills domain.
5. Attitudinal domain.

See also: DOMAINS OF LEARNING

LEARNING-HELPING. Learning-helping is the secondary, supportive function of a training system.

Learning-helping is any activity undertaken to provide an efficient learning environment for the learners.

All training system personnel contribute to the learning-helping function.

See also: LEARNING
TRAINING SYSTEM

LEARNING HIERARCHY. The learning hierarchy of a given objective is an arrangement of its essential prerequisites in a format identifying the sequencing of instruction for that objective.

See also: SEQUENCING OBJECTIVES

LEARNING OBJECTIVE.

See: PERFORMANCE OBJECTIVE

LEARNING STYLE. A particular learner's learning style is that type of sensory activity that, typically, is the best way for him or her to learn (examples: reading, listening, audio-visuals, etc.).

See also: INTERNAL CONDITIONS OF LEARNING

LEARNING TASK ANALYSIS. A component of task analysis, learning task analysis is applied to a performance objective and to its mental operations to reveal the prerequisites of learning and the desirable sequence of learning events.

The focus of learning task analysis is on the prerequisites for learning the task/performance objective.

Learning task analysis pertains both to the present conditions for learning and to the prior effects of learning.

See also: TASK ANALYSIS
INFORMATION PROCESSING ANALYSIS
TASK CLASSIFICATION

LESSON PLAN. A lesson plan is a written outline of the instruction to be conducted to help the learner achieve a particular performance objective or enabling objective.

Steps in lesson planning:

1. Identify the performance objective or enabling objective for which the lesson plan is to be written.
2. List the desired instructional events.
3. Select the ideal media.
4. Select the materials and activities.
5. Analyze the materials to identify the events they supply.
6. Plan other means of implementing the remaining events.

See also: STRATEGY OF INSTRUCTION
TACTICS OF INSTRUCTION
INSTRUCTIONAL EVENTS

LEVELS OF OBJECTIVES. The levels of objectives form a hierarchical arrangement beginning with the most general definition of the ultimate intended outcomes of learning, and proceeding to the intended achievements associated with the smallest units of instruction.

Seven levels of objectives are defined:

1. Needs.
2. Goals.
3. Life-long objectives.

4. End-of-course objectives.
5. Units of objectives.
6. Performance objectives.
7. Enabling objectives.

See also: NEED
GOAL
PERFORMANCE OBJECTIVE
ENABLING OBJECTIVE

LEVELS OF SYSTEM DESCRIPTION. The levels of human-machine system description form one dimension for organizing the system's work requirements. The levels of description address the work, itself, why the work is required, and how its requirements are to be met.

The levels of system description include three hierarchically related categories:

1. Objectives level
(What work is required, and what impediments the work faces.)

2. Functional Purposes level
(Why each Objectives level requirement exists, and the impediments that apply to satisfying each purpose.)

3. Characteristics level
(How each Functional Purposes level requirement will be met, and the impediments that apply to carrying out each Characteristics step.)

The levels of system description form one dimension of the Systems Taxonomy Model. They interact with another dimension, viz., aspects of performance, to form fifteen cells or sub-taxonomies within which any system's work requirements can be exhaustively identified and organized.

See also: SYSTEMS TAXONOMY MODEL
ASPECTS OF PERFORMANCE
OBJECTIVES-LEVEL TAXA
FUNCTIONAL PURPOSES-LEVEL TAXA
CHARACTERISTICS-LEVEL TAXA

LOGISTICS SUBSYSTEM. The Logistics Subsystem is one of the six generic, functionally oriented subsystems of any training system. Logistics Subsystem deals with maintenance of facilities and equipment; housing, feeding and recreation of training system personnel; replenishment of consumables; transportation of people and materials; general housekeeping; etc.

Logistics contributes to the learning-helping function by attending to the myriad of details necessary to keep the training system running smoothly and free of discomfort/distraction.

The principal operator or staff member of the Logistics Subsystem is the logistics supporter.

See also: TRAINING SYSTEM
LEARNING
LEARNING-HELPING

MEASURE. A measure is a judgment or appraisal of some attribute of a system.

A measure is a test or assessment of whether the attribute is "good enough" to meet the demands of the performance requirement or taxon to which the attribute is linked.

Every measure contributes an important bit of information about the system's satisfaction of the performance taxon of interest.

See also: ATTRIBUTE
TAXON
DESIGN SPECIFICATION

MEASUREMENT.

See: EVALUATION

MEASUREMENT APPLICATION.

See: MEASUREMENT PURPOSE

MEASUREMENT PURPOSE. The measurement purpose for a particular application of the Analytic Process Model to some system is the specific work of that system that is to be evaluated in the application.

A measurement purpose is equivalent to the particular sub-taxonomy of system performance requirements for which measures are to be selected and applied.

Synonym: MEASUREMENT APPLICATION

See also: TAXONOMY
MEASURE

MENTAL SKILLS DOMAIN OBJECTIVES. Performance objectives belonging to the mental skills domain require that the learner demonstrate the ability to identify, classify, use rules, or solve problems involving thinking, creating and analyzing.

See also: PERFORMANCE OBJECTIVES
LEARNING DOMAIN TAXONOMY MODELS
PHYSICAL SKILLS DOMAIN OBJECTIVES
INFORMATION DOMAIN OBJECTIVES
ATTITUDINAL DOMAIN OBJECTIVES

NEED. A need is a discrepancy or gap between the way things are and the way things ought to be.

A need exists, for example, when a person who cannot presently perform a particular job wishes or is expected to perform that job.

See also: NEEDS ASSESSMENT
TRAINING NEEDS ASSESSMENT
GOAL

NEEDS ASSESSMENT. A systematic process for determining performance goals, identifying discrepancies between goals and the current status of performance, and establishing priorities for action.

It should not be assumed that all needs (performance discrepancies) can be solved through training. Some arise due to external conditions.

Needs assessment enables the curriculum developers to focus on high-priority training needs.

See also: NEED
GOAL
TRAINING NEEDS ASSESSMENT
PROBLEM ANALYSIS

OBJECTIVES-LEVEL TAXA. Objectives-level taxa are statements of what performance is required of a system, without reference to why the performance is required or how it is required to be performed.

Objectives-level taxa include definitions of the basic capabilities, activities, and outputs expected of the system and of the relevant environmental and constraining factors that apply to those basic capabilities, activities and outputs.

Objectives-level taxa consist of the system's performance potentialities, processes, products, environment and constraints viewed at the topmost level of system description. It is a view of work requirements as objects for study in and of themselves.

See also: TAXON
FUNCTIONAL PURPOSES-LEVEL TAXA
CHARACTERISTICS-LEVEL TAXA
LEVELS OF SYSTEM DESCRIPTION
ASPECTS OF PERFORMANCE

OBJECTIVE-REFERENCED TEST. A test designed to determine a learner's achievement of a specified performance objective, enabling objective, or prerequisite.

An objective-referenced test must be keyed to the statement of the objective, and especially to the capability verb and the action verb in the statement.

The capability verb indicates the domain of learning to be addressed by the test. The action verb indicates the exact behavior that the test must elicit.

See also: ENTRY TEST
PRETEST
POSTTEST

PEER TUTORING. Peer tutoring is a training procedure in which one learner first observes, then practices and learns a task, and then demonstrates the task to another learner.

PERFORMANCE CONSTRAINTS. A system's performance constraints are the artificially imposed factors governing the circumstances and situations of the system's operation that may affect whether and how the system satisfies its work requirements.

Constraints include all man-made impediments to the system's potential, process or product performance.

See also: ASPECTS OF PERFORMANCE
PERFORMANCE ENVIRONMENT
PERFORMANCE POTENTIALITIES
PERFORMANCE PROCESSES
PERFORMANCE PRODUCTS
LEVELS OF SYSTEM DESCRIPTION

PERFORMANCE ENVIRONMENT. A system's performance environment is the set of naturally occurring factors associated with or incidental to the circumstances and situations of the system's operation that may affect the system's satisfaction of its work requirements.

The environment includes all natural impediments to the system's potential, process, or product performance.

See also: ASPECTS OF PERFORMANCE
PERFORMANCE CONSTRAINTS
PERFORMANCE POTENTIALITIES
PERFORMANCE PROCESSES
PERFORMANCE PRODUCTS
LEVELS OF SYSTEM DESCRIPTION

PERFORMANCE OBJECTIVE. Performance objectives are written explicit descriptions of specific terminal behaviors or instructional outcomes required of learners to signify successful completion of their study.

Performance objectives are statements of what the learner will be able to do, or how the learner will be expected to behave, after completing instruction.

Performance objectives identify the end products of instruction in terms of observable, measurable behavior.

The objective is a specific description of the action the learner is to exhibit after training, the conditions under which the action will take place, and the standard or criterion which must be reached for satisfactory performance.

The objective may state a directly observable action, or an observable product resulting from the action.

Performance objectives must clarify, in unambiguous terms, the behavioral competencies to be developed by the learner.

Potential errors/defects that may exist in statements of performance objectives:

1. They may refer to learners' mental processes rather than to observable actions or behaviors.

2. The performance standard may be missing or deficient.

3. The conditions may not be stated or may be poorly specified.

4. The objective may state what the facilitator does rather than what the learner will do.

5. The stated behavior may be too broad to describe specific intended outcomes adequately.

Synonyms: LEARNING OBJECTIVE
BEHAVIORAL OBJECTIVE

See also: PERFORMANCE OBJECTIVE MODELS
ENABLING OBJECTIVE
LEVELS OF OBJECTIVES
LESSON PLAN
TASK

PERFORMANCE OBJECTIVE MODELS. The three-component model (after Branson, Mager, et al.):

1. Statement of the action involved in the performance.
2. Statement of the conditions under which the action will take place.
3. Statement of how well the action must be performed.

The five-component model (after Gagne, Briggs, et al.):

1. Action--something observable that the learner will be doing.

2. Object--something concrete that the learner will produce via the action.

3. Situation--the "givens."

4. Tools and constraints--applicable to the user's implementation of the action.

5. The learning capability--that the action/object indicates has been acquired.

See also: PERFORMANCE OBJECTIVE
ENABLING OBJECTIVE

PERFORMANCE POTENTIALITIES. A system's performance potentialities are those taxa of required performance that define the basic, inherent capabilities that the system is to possess.

See also: TAXON
PERFORMANCE PROCESSES
PERFORMANCE PRODUCTS
ASPECTS OF PERFORMANCE
LEVELS OF SYSTEM DESCRIPTION

PERFORMANCE PROCESSES. A system's performance processes are those taxa of required performance that define the activities the system is to carry out, or the methods/techniques the system is to employ.

See also: TAXON
PERFORMANCE POTENTIALITIES
PERFORMANCE PRODUCTS
ASPECTS OF PERFORMANCE
LEVELS OF SYSTEM DESCRIPTION

PERFORMANCE PRODUCTS. A system's performance products are those taxa of required performance that define the goods, services or other output that the system is to deliver.

See also: TAXON
PERFORMANCE POTENTIALITIES
PERFORMANCE PROCESSES
ASPECTS OF PERFORMANCE
LEVELS OF SYSTEM DESCRIPTION

PHYSICAL SKILLS DOMAIN OBJECTIVES. Performance objectives belonging to the physical skills domain require that the learner demonstrate the ability to carry out some physical, manipulative action.

See also: PERFORMANCE OBJECTIVES
LEARNING DOMAIN TAXONOMY MODELS
INFORMATION DOMAIN OBJECTIVES
MENTAL SKILLS DOMAIN OBJECTIVES
ATTITUDINAL DOMAIN OBJECTIVES

PILOT TESTING. Pilot testing is the delivery of a newly developed program of instruction, in the actual intended operational environment, for the purpose of evaluating and improving the program.

Synonym: FIELD TRIAL

See also: FORMATIVE EVALUATION
FEEDBACK

POSTTEST. A posttest is a test of a performance objective or enabling objective, administered subsequent to delivery of prescribed training for that objective.

Posttests provide the basis for determining whether particular learners require additional training, or whether they can be certified as having achieved a given set of performance objectives.

See also: OBJECTIVE-REFERENCED TEST
ENTRY TEST
PRETEST

PREDICTIVE VALIDITY OF TRAINING. The predictive validity of the training undertaken to pursue a particular performance objective is the correlation between a learner's posttest score on that objective and the learner's subsequent job performance measure on the corresponding task.

See also: POSTTEST
JOB PERFORMANCE MEASURE
PERFORMANCE OBJECTIVE

PREREQUISITE. A prerequisite is a performance objective which candidate learners are expected to have achieved prior to the prescribed training.

See also: PERFORMANCE OBJECTIVE
ESSENTIAL PREREQUISITE
SUPPORTIVE PREREQUISITE
ENTRY TEST

PRESENT CONDITION OF LEARNING. The present condition of learning is that which the learner must recall to make achievement of the particular performance objective possible.

The present condition of learning is revealed by Learning Task Analysis.

See also: LEARNING TASK ANALYSIS
INTERNAL CONDITIONS OF LEARNING

PRETEST. A pretest is a test of a performance objective or enabling objective, administered prior to delivery of the prescribed training for that objective.

Pretests provide the basis for determining whether particular learners should "skip" blocks of instruction corresponding to objectives already achieved.

See also: OBJECTIVE-REFERENCED TEST
ENTRY TEST
POSTTEST

PROBLEM ANALYSIS. Given evidence of a failure or discrepancy in performance, problem analysis is conducted to determine whether the problem/need should be solved by means of training, equipment, administrative action, or some other method.

See also: NEEDS ASSESSMENT

PROMPTING. Prompting is providing direct guidance to a learner by supplying a specific fact, procedure, word, phrase, etc., that the learner is attempting to recall.

See also: GENERAL LEARNING GUIDELINES
CUE

PURPOSES OF AN INSTRUCTIONAL UNIT. Identification of the purposes of an instructional unit provides a first step toward defining the performance objectives of that unit.

The stated instructional purposes must:

1. Identify what learners will do after or as a result of the instruction, not what they will do during the instruction.

2. Identify current or immediate outcomes expected of the instruction, not long-range, future outcomes.

REMEDIAL TRAINING. The remedial training conducted in support of a particular program of instruction is the training given to certain candidate learners to help them achieve performance objectives that are considered prerequisites for the program of instruction.

See also: ENTRY TEST
ESSENTIAL PREREQUISITE
SUPPORTIVE PREREQUISITE

SEQUENCING INSTRUCTION.

See: SEQUENCING OBJECTIVES

SEQUENCING OBJECTIVES. Sequencing objectives is the process of determining the order in which performance objectives and enabling objectives will be pursued during training. Proper sequencing demands that objectives be pursued in a logical "stepping-stone" fashion. Specifically, an objective should not be pursued until those that are essential or helpful for its pursuit have first been achieved.

In sequencing objectives for pursuit during training:

1. Place dependent objectives after those on which they depend.

2. Of two supportive objectives, the one that is easier/cheaper to achieve should be placed first.

Possible errors that may occur in sequencing objectives:

1. A supportive relationship could be misinterpreted as a dependent relationship, and result in increased training time and expense.

2. A dependent relationship could be misinterpreted as independent, and result in a very difficult-to-achieve sequence.

3. A supportive relationship might not be recognized, and result in inefficient instruction.

Synonym: SEQUENCING INSTRUCTION

See also: DEPENDENT OBJECTIVE
SUPPORTIVE OBJECTIVES

STIMULUS OF A TASK. The stimulus of a task is that which "triggers" the performance of the task by the job performer.

STIMULUS OF INFORMATION PRESENTATION. The stimulus for a particular block of information is the form in which that block is presented to the learner.

STM.

See: SYSTEMS TAXONOMY MODEL

STRATEGY OF INSTRUCTION. The strategy of instruction for a given performance objective consists of 1) determining the sequence of pursuit of enabling objectives for that performance objective, and 2) choosing how to implement instructional events for each enabling objective.

See also: LESSON PLAN
TACTICS OF INSTRUCTION

SUBSYSTEM. A subsystem of a particular human-machine system of interest is, itself, a human-machine system that is subservient to the system of interest in the work it performs.

Subsystems may be totally contained within the system of interest.

Subsystems are members of the system hierarchy of the system of interest.

See also: HUMAN-MACHINE SYSTEM
SYSTEM HIERARCHY

SUMMATIVE EVALUATION. Summative evaluation is the process of gathering, combining and interpreting data to measure the effectiveness of a training system operating at full-scale delivery.

Summative evaluation occurs after all formative evaluation has been completed.

See also: FORMATIVE EVALUATION

SUPPORTIVE OBJECTIVES. Two performance objectives, or two enabling objectives, are supportive of one another when achievement of one facilitates achievement of the other, regardless of the order of achievement.

If two objectives are supportive of one another, the one that is easier/cheaper to achieve should be pursued first, during training.

See also: DEPENDENT OBJECTIVE
INDEPENDENT OBJECTIVES
PERFORMANCE OBJECTIVE
SEQUENCING OBJECTIVES

SUPPORTIVE PREREQUISITE. A supportive prerequisite for a particular performance objective or enabling objective is a performance capability that is not actually incorporated within the objective, but which makes it easier to learn/achieve the objective.

Learners who possess the supportive prerequisite will usually achieve the objective more readily than will learners who do not possess it.

See also: PERFORMANCE OBJECTIVE
ENABLING OBJECTIVE
SUPPORTIVE OBJECTIVES
DEVELOPMENT OF OBJECTIVES
ESSENTIAL PREREQUISITE

SUPRASYSTEM. A suprasystem of a particular human-machine system of interest is, itself, a human-machine system to which the system of interest is subservient in the work it performs.

The system of interest may be totally contained within the suprasystem.

Suprasystems are members of the system hierarchy of the system of interest.

See also: HUMAN-MACHINE SYSTEM
SYSTEM HIERARCHY

SYSTEM.

See: HUMAN-MACHINE SYSTEM

SYSTEM HIERARCHY. The system hierarchy surrounding a particular human-machine system of interest is the network of other systems with which the system of interest interacts in the performance of its work.

System hierarchy is one dimension of the Systems Taxonomy Model.

See also: HUMAN-MACHINE SYSTEM
COLLATERAL SYSTEM
SUBSYSTEM
SUPRASYSTEM
SYSTEMS TAXONOMY MODEL

SYSTEMS TAXONOMY MODEL. The Systems Taxonomy Model is a conceptual framework and a set of analytic procedures for identifying the performance requirements (or taxa) associated with a system of interest.

The Systems Taxonomy Model is the first stage of the Analytic Process Model.

The Systems Taxonomy Model identifies and organizes the performance taxa of a system of interest along three dimensions:

1. System Hierarchy--This dimension insures that work requirements will be identified by studying the system of interest, itself, as well as by studying the work requirements imposed upon the system of interest by other, interacting systems that are linked to it hierarchically.

2. Aspects of Performance--This dimension insures that the identified work requirements will include not only what the system is to produce, but also the processes it is to carry out, the capabilities it is to possess, and the circumstances under which it is to operate.

3. Levels of System Description--This dimension insures that the work requirements will be identified not only in terms of what is expected, but also why it is needed and how it is supposed to be accomplished.

Synonym: STM

See also: ANALYTIC PROCESS MODEL
TAXON
TAXONOMY
ASPECTS OF PERFORMANCE
LEVELS OF SYSTEM DESCRIPTION
SYSTEM HIERARCHY

TACTICS OF INSTRUCTION. Tactics of instruction are the specific details or prescriptions for the instructional events in a lesson plan, with special reference to how the needed conditions of learning are incoprorated into the events.

See also: LESSON PLAN
STRATEGY OF INSTRUCTION
CONDITIONS OF LEARNING

TASK. A task is an element of a job. A task can be described in terms of a discrete, observable action carried out by the job performer. Every task must be addressed in the training provided for the job. Any given task may be represented by a performance objective, an enabling objective, or a prerequisite.

See also: JOB ANALYSIS
TASK ANALYSIS
PERFORMANCE OBJECTIVE

TASK ANALYSIS. The analysis of an individual task, or performance objective, to provide a basis for determining the appropriate teaching-learning strategy for that task/objective.

Task analysis has three components:

1. Information processing analysis.
2. Task classification.
3. Learning task analysis.

Task analytic products:

1. Information-processing diagram showing the mental operations involved in each performance objective.

2. Classification of each objective into the appropriate class of learning outcome, or domain of learning.

3. Specification of essential and supportive prerequisites for each performance objective.

Synonym: ANALYSIS OF PERFORMANCE OBJECTIVES

TASK CLASSIFICATION. A component of Task Analysis, task classification categorizes a performance objective as to its domain of learning.

Task classification provides a means of identifying the necessary conditions of learning that are to be included in instructional events.

See also: TASK ANALYSIS
INFORMATION PROCESSING ANALYSIS
LEARNING TASK ANALYSIS
LEARNING DOMAIN TAXONOMY MODELS

TAXON. A particular category or class pertaining to some thing or concept of interest.

A taxon is an element of a taxonomy.

A system performance taxon is a particular type or category of performance that is required of a system of interest.

See also: TAXONOMY
SYSTEMS TAXONOMY MODEL
ASPECTS OF PERFORMANCE
LEVELS OF SYSTEM DESCRIPTION

TAXONOMY. (When written with an initial capital "T"): The science or technique of classification, as in the technique of classifying and organizing the performance requirements of a human-machine system.

(When written with a lower case "t"): A particular classification of things or concepts, as in a classification and organization of a particular system's performance requirements.

See also: TAXON
SYSTEMS TAXONOMY MODEL

TEST.

See: OBJECTIVE-REFERENCED TEST

TEST DISTORTION. Test distortion is a defect in a test resulting from the fact that the test can be answered/performed successfully by applying a domain of learning and/or action other than that intended to be tested.

See also: OBJECTIVE-REFERENCED TEST
TEST RELIABILITY
TEST VALIDITY

TEST RELIABILITY. The reliability of a test is assessed by examining whether the test requires the learner to perform the action verb long enough/often enough to permit a dependable inference that the objective has been demonstrated.

See also: OBJECTIVE-REFERENCED TEST
ACTION VERB
TEST DISTORTION
TEST VALIDITY

TEST VALIDITY. The validity of a test is assessed by comparing the test with the objective it is intended to measure. The action, situation, standards, etc., of the test must conform exactly to those of the objective.

See also: OBJECTIVE-REFERENCED TEST
PERFORMANCE OBJECTIVE
TEST DISTORTION
TEST RELIABILITY

TRAINING NEEDS ASSESSMENT. Training needs assessment is a process for determining what should be taught/learned. The process is based on the active involvement of those directly affected by the training system (e.g., the learners), in addition to professional educators.

Training needs assessment consists of:

1. Analysis of the job to be trained.
2. Selection of the tasks to be trained.
3. Construction of job performance measures for the selected tasks.
4. Analysis of existing courses.
5. Selection of the instructional setting for each task to be trained.

See also: ANALYSIS
NEED
NEEDS ASSESSMENT

TRAINING SYSTEM. A training system is a particular type of human-machine system, intended to accomplish two major functions: learning, and learning-helping.

Training systems have six types of operators, or staff members: learners, facilitators, administrators, curriculum developers, facilities developers, and logistic supporters.

Training systems have six functionally oriented subsystems, each of which is operated principally by one of the types of operators:

Command (training administrator)
Design (curriculum developer)
Emplacement (facilities developer)
Logistics (logistics supporter)
Enabling (facilitator)
Delivery (learner)

See also: LEARNING
LEARNING-HELPING
COMMAND SUBSYSTEM
DESIGN SUBSYSTEM
EMPLACEMENT SUBSYSTEM
LOGISTICS SUBSYSTEM
ENABLING SUBSYSTEM
DELIVERY SUBSYSTEM
HUMAN-MACHINE SUBSYSTEM

TRAIT. A trait is a qualitative or quantitative property (aptitude, expertise, strength, reliability, etc.) possessed by a system component (person, equipment or procedure) which is necessary in order to achieve or satisfy a performance taxon of interest. The presence of a trait is determined by one or more concrete, observable attributes.

APPENDIX A

Training Design Subsystem Data Base

Final Summary Report
February 28, 1983
Illustration of Design Subsystem

Measurement Purpose: Global

System Class: Training[4]
System: Bradley Infantry Fighting Vehicle Training System (BIFVTS)[9054]
Subsystem: Design[3]

1.0.0.0.0.0. Potentialities: The system must be capable of:
- 1.1.0.0.0.0. Identifying goals and priorities
  - 1.1.0.0.1.0. Scope of information available concerning BIFVG operations
  - 1.1.0.0.2.0. Staff experience and qualifications in identifying training goals
  - 1.1.0.0.3.0. Planned approach to identify BIFVG training goals
  - 1.1.0.0.4.0. Resources allocated to identifying BIFVG training goals
- 1.1.1.0.0.0. Defining the total scope of learning
  - 1.1.1.0.1.0. Aspects of each gunnery training goal to be defined
  - 1.1.1.0.2.0. Plans for defining the total scope of BIFVG learning
  - 1.1.1.1.0.0. Identifying types of achievements relevant to the intended job
    - 1.1.1.1.1.0. Types or classes of achievement intended to be identified
    - 1.1.1.1.2.0. Plans for identifying all types of BIFVG achievements
  - 1.1.1.2.0.0. Analyzing achievements to determine suitability for training
- 1.1.2.0.0.0. Stating the ultimate intended outcomes of learning
  - 1.1.2.0.1.0. Elements of ultimate outcomes that are intended to be stated
  - 1.1.2.0.2.0. Intended formats to state ultimate intended outcomes of BIFVG lrng
  - 1.1.2.0.3.0. Plans for stating ultimate intended outcomes
  - 1.1.2.1.0.0. Determining necessary levels of achievement
    - 1.1.2.1.1.0. Elements or factors of necessary levels intended to be determined
    - 1.1.2.1.2.0. Plans for determining necessary levels of BIFVG achievement
  - 1.1.2.2.0.0. Determining existing levels of achievement
    - 1.1.2.2.1.0. Elements of the current levels of achievement intended to be tested
    - 1.1.2.2.2.0. Plans for testing candidates' current levels of BIFVG achievement
  - 1.1.2.3.0.0. Discerning discrepancies between existing and necessary levels
- 1.1.3.0.0.0. Identifying the relative importance of intended outcomes
  - 1.1.3.1.0.0. Assessing goal importance
  - 1.1.3.2.0.0. Insuring availability of a relative (numeric) goal ranking scheme
- 1.1.4.0.0.0. Establishing a basis for specifying learning objectives
  - 1.1.4.0.1.0. Elements of the basis intended to be established

1.1.4.0.2.0. Plans for establishing the basis for specifying BIFVG perform obj
1.1.4.1.0.0. Insuring availability of a hierarchy/taxonomy of objectives
1.1.4.1.1.0. Goal taxa intended to be employed
1.1.4.1.2.0. Plans for employing the taxa to classify goals for BIFVG training
1.1.4.2.0.0. Stating goals in terms that imply behaviors
1.1.4.2.1.0. Behavioral terminology intended for use in stating BIFVG goals
1.1.4.2.2.0. Intended formats for stating BIFVG training goals
1.2.0.0.0.0. Establishing performance objectives
1.2.0.0.1.0. Scope of information availabe concerning BIFVG task
1.2.0.0.1.1. BIFVG required tasks that are Known (list & descrb each)
1.2.0.0.1.2. BIFVG required tasks that are unknown to Design Subsystem(list ea)
1.2.0.0.1.3. Tasks that are not reqd of BIFVG but Design Subsys classif as reqd
1.2.0.0.2.0. Staff experience and qualifications in establishing perform objctvs
1.2.0.0.2.1. Revwrs cum ratings of ea Design staff qual to estab trng perf obj
1.2.0.0.2.2. Revwrs overall assessment of total Design staff qual
1.2.0.0.3.0. Planned approach to establishing BIFVG performance objectives
1.2.0.0.3.1. Essential steps missing from plans (list & describe ea)
1.2.0.0.3.2. Inessential steps included in plans (list & describe ea)
1.2.0.0.3.3. Inconsistencies/deficiencies in sequencing steps in plans
1.2.0.0.3.4. Reviewers cum ratings of soundness/workability of plans
1.2.0.0.4.0. Resources allocated to establishing BIFVG performance objectives
1.2.0.0.4.1. % of reqd person-hrs proposed for alloc to establish objectives
1.2.0.0.4.2. % of reqd materials/goods proposed for alloc to establish objctvs
1.2.0.0.4.3. % of reqd support services proposed for alloc to establish objctvs
1.2.0.0.4.4. Ratio of $ proposed to $ needed for establishing objectives
1.2.1.0.0.0. Stating expected performance and behavior after training
1.2.1.0.1.0. Elements or factors of gunner abilities intended to be stated
1.2.1.0.1.1. Essential elements of abilities to be incl in stmt of BIFVG ablty
1.2.1.0.1.2. Inessential elements intended to be incl in stmt of BIFVG ablties
1.2.1.0.1.3. Essential elements of ablties not to be incl in BIFVG ablty stmt
1.2.1.0.2.0. Intended formats for stating BIFV gunner abilities
1.2.1.0.2.1. Rvwrs rtngs of quality of intended formats
1.2.1.0.2.2. Specific deficiencies in intended formats identified by rvwrs
1.2.1.0.3.0. Plans for stating intended abilities
1.2.1.0.3.1. Essential steps missing from plan for producing stmt of ablty
1.2.1.0.3.2. Inessential/inappropriate steps included in the plans
1.2.1.0.3.3. Inconsistencies/deficiencies in sequencing of steps in plans
1.2.1.0.3.4. Deficiencies in staff's abilities to carry out particular plans
1.2.1.0.3.5. Deficiencies in resources allocated to implement particular plans
1.2.1.1.0.0. Defining the performance action

1.2.1.1.1.0. Types of BIFV gunner performance actions intended to be defined
  1.2.1.1.1.1. Relevant types of actions not intended to be defined
  1.2.1.1.1.2. Irrelevant types of actions intended to be defined
  1.2.1.1.1.3. Reviewers' ratings of observability of types of actions defined
1.2.1.1.2.0. Plans for defining actions required of BIFV gunners
  1.2.1.1.2.1. Essential steps missing from plans for def perm actions
  1.2.1.1.2.2. Nonessential steps included in the plans
  1.2.1.1.2.3. Inconsistencies/deficiencies in sequencing steps in plans
  1.2.1.1.2.4. Deficiencies in staff abilities to carry out plans
  1.2.1.1.2.5. Deficiencies in resources allocated to implementing plans
1.2.1.2.0.0. Defining the performance conditions
1.2.1.2.1.0. Elements or types of BIFV gunner perfm conditions to be defined
  1.2.1.2.1.1. Relevant elements/types of conditions not intended to be defined
  1.2.1.2.1.2. Irrelevant elements/types of conditions intended to be defined
1.2.1.2.2.0. Plans for defining the BIFV gunnery performance conditions
  1.2.1.2.2.1. Essential steps missing from plans for defining perfm conditions
  1.2.1.2.2.2. Inessential/inappropriate steps included in plans
  1.2.1.2.2.3. Inconsistencies/deficiencies in sequencing steps in plans
  1.2.1.2.2.4. Deficiencies in staff abilities to carry out plans
  1.2.1.2.2.5. Deficiencies in resources allocated to implementing plans
1.2.1.3.0.0. Defining the performance standard
1.2.1.3.1.0. Elements or factors of BIFV gunner perf stds to be defined
  1.2.1.3.1.1. Relevant elements/factors of perfm stds not intended to be defined
  1.2.1.3.1.2. Irrelevant elements or factors of prfm stds intended to be defined
1.2.1.3.2.0. Plans for defining the standards of BIFV gunnery performance
  1.2.1.3.2.1. Essential steps missing from plans for defining perf standards
  1.2.1.3.2.2. Inessential/innappropriate steps included in plan
  1.2.1.3.2.3. Inconsistencies/deficiencies in sequencing of steps in plan
  1.2.1.3.2.4. Deficiencies in staff abilities to carry out plans
  1.2.1.3.2.5. Deficiencies in resources allocated to implementing plans
1.2.2.0.0.0. Providing a basis for objectively assessing learner performance
1.2.2.0.1.0. Elements of the basis for assessment intended to be provided
  1.2.2.0.1.1. Essential elements/sgmnts of basis for obj assesmnt to be provided
  1.2.2.0.1.2. Inessential elements/sgmnts of basis intended to be provided
  1.2.2.0.1.3. Essential elements/sgmnts of basis not to be provided
1.2.2.0.2.0. Plans for providing a basis for objectively assessing BIFVG perform
  1.2.2.0.2.1. Essential steps missing from plans for providing basis of assmnt
  1.2.2.0.2.2. Inessential/inappropriate steps included in the plans
  1.2.2.0.2.3. Inconsistencies/deficiencies in sequencing of steps in plans
  1.2.2.0.2.4. Deficiencies in staff's abilities to carry out particular plans

1.2.2.0.2.5. Deficiencies in resourses allocated to implementing these plans
1.2.2.1.0.0. Developing pretest items
1.2.2.1.1.0. Types of BIFV gunnery pretest items to be developed
1.2.2.1.1.1. Relevant types of pretest items not intended to be developed
1.2.2.1.1.2. Irrelevant/innappropriate types o pretest items intended to be devel
1.2.2.1.2.0. Plans for developing BIFV gunnery pretest items
1.2.2.1.2.1. Essential steps missing from plans for dev pretest items
1.2.2.1.2.2. Inessential/innappropriate steps included in plans
1.2.2.1.2.3. Inconsistencies/deficiencies in sequencing steps in plans
1.2.2.1.2.4. Deficiencies in staff abilities to carry out plans
1.2.2.1.2.5. Deficiencies in resources allocated to implementing plans
1.2.2.2.0.0. Developing posttest items
1.2.2.2.1.0. Types of BIFV gunnery posttest items to be developed
1.2.2.2.1.1. Relevant types of posttest items not intended to be developed
1.2.2.2.1.2. Irrelevant/inappropriate types of posttest items intended/developed
1.2.2.2.2.0. Plans for developing BIFV gunnery posttest items
1.2.2.2.2.1. Essential steps missing from plans for devel posttest items
1.2.2.2.2.2. Inessential/inappropriate steps included in plans
1.2.2.2.2.3. Inconsistencies/deficiencies in sequencing steps in plans
1.2.2.2.2.4. Deficiences in staff abilities to carry out plans
1.2.2.2.2.5. Deficiences in resources allocated to implementing plans
1.3.0.0.0.0. Analyzing performance objectives
1.3.0.0.1.0. Intended scope of analysis of BIFVG performance objectives
1.3.0.0.2.0. Staff experience and qualifications in analyzing perform objectives
1.3.0.0.3.0. Planned approach to analyzing BIFVG performance objectives
1.3.0.0.4.0. Resources allocated to analyzing BIFVG performance objectives
1.3.1.0.0.0. Identifying prerequisites to learning
1.3.1.0.1.0. Types or classes of BIFVG prerequisites intended to be identified
1.3.1.0.2.0. Plans for identifying BIFVG training prerequisites
1.3.1.1.0.0. Revealing present conditions of learning (what learners must recall)
1.3.1.1.1.0. Types of information recall requirements intended to be revealed
1.3.1.1.2.0. Plans for revealing the BIFVG recall requirements
1.3.1.2.0.0. Identifying essential prerequisites (capabilities within objective)
1.3.1.2.1.0. Types of essential prerequisite abilities intended to be revealed
1.3.1.2.2.0. Plans for revealing BIFVG essential prerequisite abilities
1.3.1.3.0.0. Identifying supportive prerequisites (capabilities to promote objectives)
1.3.1.3.1.0. Types of supportive prerequisite abilities intended to be revealed
1.3.1.3.2.0. Plans for revealing BIFV gunners supportive prerequisite abilities
1.3.2.0.0.0. Providing basis for objectively assessing candidate learner's suitability
1.3.2.0.1.0. Elements of basis for candidate assessment intended to be provided

1.3.2.0.2.0. Plans to provide basis to assess candidate BIFV gunner
1.3.2.1.0.0. Developing entry test items
1.3.2.1.1.0. Scope of BIFVG abilities intended for entry testing
1.3.2.1.2.0. Plans for specifying entry test items for candidate BIFV gunners
1.3.3.0.0.0. Identifying interactions/dependence among objectives
1.3.3.1.0.0. Discerning independence between objectives
1.3.3.2.0.0. Discerning dependence between objectives
1.3.3.3.0.0. Discerning supportive relationship between objectives
1.3.4.0.0.0. Classifying objectives in terms of domains of learning
1.3.4.0.1.0. Domains of lrng intended for use to classify BIFVG perform objctvs
1.3.4.0.2.0. Plans for classifying BIFVG performanc objectives into lrng domains
1.3.4.1.0.0. Identifying information type objectives
1.3.4.1.1.0. Criteria intended to classify BIFVG perform obj as info-type objctv
1.3.4.2.0.0. Identifying mental skills type objectives
1.3.4.2.1.0. Criteria intended to classify BIFVG perf obj as mental skills obj
1.3.4.3.0.0. Identifying physical skills type objectives
1.3.4.3.1.0. Criteria intended to classify BIFVG perf obj as physical skill obj
1.3.4.4.0.0. Identifying attitude type objectives
1.3.4.4.1.0. Criteria to classify BIFVG perf obj as attitude-type obj
1.3.5.0.0.0. Identifying component steps or processes within the objectives
1.3.5.0.1.0. Types or classes of gunners' component steps or procs to be ID'd
1.3.5.0.2.0. Plans for id gunners' steps or processes within BIFVG perf obj
1.3.5.1.0.0. Identifying overt steps
1.3.5.1.1.0. Types of overt steps intended to be identified
1.3.5.1.2.0. Plans for identifying overt steps involved in BIFVG performance obj
1.3.5.2.0.0. Identifying covert steps
1.3.5.2.1.0. Types of covert steps intended to be identified
1.3.5.2.2.0. Plans for identifying covert steps involved in BIFVG perform obj
1.3.5.3.0.0. Identifying unconscious steps
1.3.5.3.1.0. Types of unconscious steps intended to be identified
1.3.5.3.2.0. Plans to id unconscious steps involved in BIFVG perform objectives
1.4.0.0.0.0. Defining training content
1.4.1.0.0.0. Selecting stimuli for each objective
1.4.1.1.0.0. Defining propositions, names, facts, etc., for info objectives
1.4.1.2.0.0. Defining concepts, rules, algorithms, etc., re mental skills objectives
1.4.1.3.0.0. Defining movements, timings, actions, etc., re physical skills objectives
1.4.1.4.0.0. Defining values, choices, etc., re attitudinal objectives
1.4.2.0.0.0. Selecting instructional setting for each objective
1.4.2.1.0.0. Assessing applicability of Job Performance Aids (JPAs)
1.4.2.2.0.0. Assessing applicability of Self-Teaching Exportable Packages (STEPs)

1.4.2.3.0.0. Assessing applicability of Formal On-the-Job Training (FOJT)
1.4.2.4.0.0. Assessing applicability of Installation Support School (ISS)
1.4.2.5.0.0. Assessing applicability of Resident School (RS)
1.4.3.0.0.0. Defining instructional sequence
1.4.3.1.0.0. Sequencing in dependency order
1.4.3.2.0.0. Sequencing in supportive relationship (efficiency) order
1.5.0.0.0.0. Defining training procedures
1.5.0.0.1.0. Categories of BIFVG training procedures intended to be defined
1.5.0.0.2.0. Staff experience and qualifications in definition of training procs
1.5.0.0.3.0. Planned approach to defining BIFV gunnery training procedures
1.5.0.0.4.0. Resources allocated to defining BIFV gunnery training procedures
1.5.1.0.0.0. Specifying preparation procedures
1.5.1.1.0.0. Defining facilitator preparation activities
1.5.1.2.0.0. Defining facilities preparation requirements
1.5.1.3.0.0. Defining attention-gaining procedures
1.5.1.4.0.0. Defining objective-informing procedures
1.5.1.5.0.0. Defining procedures for stimulating learners' recall of prerequisites
1.5.2.0.0.0. Specifying presentation procedures
1.5.2.1.0.0. Defining presentation media/media
1.5.2.2.0.0. Defining procedures and requirements for placing emphasis
1.5.2.3.0.0. Defining procedures for enhancing learners' comprehension & retention
1.5.3.0.0.0. Specifying application procedures
1.5.3.0.1.0. Classes/method of BIFVG application intended to be specified
1.5.3.0.2.0. Intended involvement of testing in BIFVG application
1.5.3.0.3.0. Plans for specifying BIFVG application procedures
1.5.3.1.0.0. Defining procedures for enhancing learners' involvement/participation
1.5.3.2.0.0. Defining procedures for eliciting performance from learners
1.5.3.3.0.0. Defining procedures for providing learning guidance to learners
1.5.3.4.0.0. Defining procedures for providing learning feedback to learners
1.5.3.4.1.0. Intended role of learning feedback in BIFVG application procedures
1.5.3.4.2.0. Intended contribution of testing to BIFVG learning feedback
1.5.3.4.3.0. Plans for providing BIFVG learning feedback
1.5.3.5.0.0. Defining procedures for assessing sufficiency of practice
1.5.3.5.1.0. Criteria intended to be employed to assess sufficiency of practice
1.5.3.5.2.0. Intended contribution of testing to employment of those criteria
1.5.3.5.3.0. Plans for enabling BIFVG learners to assess sufficiency of practice
1.5.4.0.0.0. Specifying (learner) evaluation procedures
1.5.4.0.1.0. Categories/methods of BIFVG evaluation intended for specification
1.5.4.0.2.0. Plans for specifying BIFVG evaluation procedure
1.5.4.1.0.0. Defining procedures to assess the proper domains of learning

1.5.4.1.1.0. Plans for tailoring test specs to domain of objective to be tested
1.5.4.2.0.0. Defining procedures to assess the appropriate action/behavior
1.5.4.2.1.0. Plans for tailoring test specifications to action called for in obj
1.5.4.3.0.0. Defining procedures to insure assessment reliability
1.5.4.3.1.0. Plans to tailor specs to conds & standards appropriate to objctvs
1.5.4.3.2.0. Plans for devising test specs that support stat reliability req
1.6.0.0.0.0. Evaluating the curriculum
1.6.0.0.1.0. Intended scope of BIFVG training curriculum evaluation
1.6.0.0.2.0. Staff experience and qualifications in eval of training curricula
1.6.0.0.3.0. Planned approach to evaluating the BIFVG training curriculum
1.6.0.0.4.0. Resources allocated to evaluating BIFVG training curriculum
1.6.1.0.0.0. Validating/revising the bases for the developing curriculum
1.6.1.0.1.0. Intended elements/methods of curriculum basis validation/revision
1.6.1.0.2.0. Intended contribution of BIFVG testing to those elements/methods
1.6.1.0.3.0. Plans for validating/revising bases for dvloping BIFVG trng currclm
1.6.1.1.0.0. Entry-level testing of representative candidate learners
1.6.1.1.1.0. Assumptions re prerequisites and candidates qualifications
1.6.1.1.2.0. Intended contribution of BIFVG entry-level testing
1.6.1.1.3.0. Plans for specifying and conducting BIFV entry-level gunner testing
1.6.1.2.0.0. Post-training testing of representative job incumbents
1.6.1.2.1.0. Conclusions concerning performance objectives & test specifications
1.6.1.2.2.0. Intended contribution of BIFV post-training testing
1.6.1.2.3.0. Plans for spec & conduct BIFV post-trng to verify conclusions
1.6.2.0.0.0. Validating/revising the developing curriculum itself
1.6.2.0.1.0. Intended elements/methods of curric validation/revision to be used
1.6.2.0.2.0. Intended contrib of BIFVG testing to those elements/methods
1.6.2.0.3.0. Plans for validating/revising developing BIFVG training curriculum
1.6.2.1.0.0. Obtaining error data
1.6.2.1.1.0. Aspects/segments of curriculum intended for 'pilot training'
1.6.2.1.2.0. Intended role of BIFVG testing in 'pilot training'
1.6.2.1.3.0. Plans for spec & conduct BIFVG testing in conjunction w/ pilot trng
1.6.2.2.0.0. Obtaining design feedback
1.6.2.2.1.0. Aspects/segments of curclm for which job perfm meas are to be dvlpd
1.6.2.2.2.0. Plans for correlating job performance meas w/ pilot trng test scors
1.6.2.3.0.0. Correlating post-test data with subsequent job performance
2.0.0.0.0.0. Processes: The system must carry out the following activities:
2.1.0.0.0.0. Analyze the job for which training is to be developed
2.1.1.0.0.0. Identify the tasks that are involved in the job
2.1.1.1.0.0. Review job specification/description
2.1.1.2.0.0. Interview job/system designers

2.1.1.3.0.0. Observe job incumbents
2.1.1.4.0.0. Interview job incumbents
2.1.1.5.0.0. Prepare tentative task list
2.1.1.6.0.0. Authenticate tentative task list using representative job designrs/incumbents
2.1.1.7.0.0. Validate task list using other representatives
2.1.2.0.0.0. Determine the sequence and stimuli of the tasks
2.1.2.1.0.0. Review job specification/description
2.1.2.2.0.0. Interview job/system designers
2.1.2.3.0.0. Observe job incumbents
2.1.2.4.0.0. Interview job incumbents
2.1.2.5.0.0. Prepare tentative task flowchart
2.1.2.6.0.0. Prepare tentative task stimuli specifications
2.1.2.7.0.0. Authenticate tntv flowchart & stimuli specs using rpsntv job dsgnrs/incmbents
2.1.2.8.0.0. Validate flowchart and stimuli specifications using other representatives
2.1.3.0.0.0. Determine the level of skill or performance deemed adequate for the job
2.1.3.1.0.0. Review job specification/description
2.1.3.2.0.0. Interview job/system designers
2.1.3.3.0.0. Interview job supervisors/commanders
2.1.3.4.0.0. Observe/interview "high"-rated incumbents
2.1.3.5.0.0. Observe/interview "low"-rated incumbents
2.1.3.6.0.0. Prepare tentative skill/performance specifications
2.1.3.7.0.0. Authenticate prfmnce specs using representative dsgnrs/supervisors/incumbents
2.1.3.8.0.0. Validate performance specifications using other representatives
2.2.0.0.0.0. Assess tasks for training development
2.2.1.0.0.0. Determine needs for training as a function of task
2.2.1.1.0.0. Develop trng needs criteria in concert w/represntv system users/designers
2.2.1.2.0.0. Rate tasks in accordance with the specified criteria
2.2.2.0.0.0. Allocate training development and delivery resources
2.2.2.1.0.0. Determine degree of learning difficulty for each task requiring training
2.2.2.2.0.0. Determine degree of instruction needed for each such task
2.3.0.0.0.0. Analyze tasks selected for training
2.3.0.0.1.0. Task analytic methods applied to the BIFVG tasks
2.3.0.0.1.1. Deviations between methods applied and methods specified in plans
2.3.0.0.1.2. Aspects/elements of method irrelevant to or inconsistent w/ purpose
2.3.0.0.1.3. Aspects/elements missing from methods essential for analytic purp
2.3.0.0.1.4. Types of data needed for methods that were not obtained
2.3.0.0.2.0. The scope of the BIFVG task analyses conducted
2.3.0.0.2.1. Factors supposed to be determined from task analysis that were not
2.3.0.0.2.2. Factors irrelevant to analytic purp that were determined in anlysis
2.3.0.0.3.0. Completeness of the BIFVG task annlyses conducted

2.3.0.0.3.1. Relevant BIFV gunner tasks to which analytic methods not applied

2.3.0.0.3.2. Factors missing from analysis applied to other relevant BIFVG tasks

2.3.0.0.4.0. Accuracy of the BIFVG task analyses conducted

2.3.0.0.4.1. Inaccuracies in input data obtained for applic of analytic methods

2.3.0.0.4.2. Specific misinterpretations of analyzed data

2.3.0.0.4.3. Aspects/elements of analytic methods that were misapplied

2.3.1.0.0.0. Identify the information processing entailed in the task

2.3.1.1.0.0. Analyze decision flow to reduce processing to sequence of binary decisions

2.3.1.2.0.0. Analyze the decision levels in terms of nature, complexity, and time

2.3.2.0.0.0. Classify the tasks in terms of the domains of learning involved

2.3.2.0.1.0. Methods employed to identify domains of lrng of BIFVG tasks

2.3.2.0.1.1. Aspects/elements of methods irrelevant/inconsistent with id

2.3.2.0.1.2. Aspects/elements missing from methods that are essential for id

2.3.2.0.1.3. Input data required for methods that are missing/insufficient

2.3.2.0.2.0. Domains of learning identified for each BIFVG task

2.3.2.0.2.1. Domains identified as involved in task that are irrelevant

2.3.2.0.2.2. Domains not identified as relevant that are

2.3.2.1.0.0. Identify knowledge to be acquired

2.3.2.1.1.0. Methods employed to identify knowledge required for BIFV gunr tsks

2.3.2.1.1.1. Elements of methods irrelevant to identify knowl reqd to do tasks

2.3.2.1.1.2. Elements missing from methods essential to id knowledge reqd

2.3.2.1.1.3. Input data reqd for methods that are missing or insufficient

2.3.2.1.2.0. Knowledge requirements identified for BIFV gunner tasks

2.3.2.1.2.1. Knowledge elements id as reqd but actually are not reqd to do task

2.3.2.1.2.2. Knowledge elements not id as reqd but actually are reqd to do task

2.3.2.2.0.0. Identify mental skills to be acquired

2.3.2.2.1.0. Methods employed to id mental skill requirements of BIFV gun tsks

2.3.2.2.1.1. Aspects of methods irrel to id of mental skills reqd to do task

2.3.2.2.1.2. Aspects missing from methods essential to id mental skills reqd

2.3.2.2.1.3. Input data reqd for methods that are missing or insufficient

2.3.2.2.2.0. Mental skill requirements identified for BIFV gunner tasks

2.3.2.2.2.1. Mental skills id as reqd for task that are not needed to do task

2.3.2.2.2.2. Mental skills not id as reqd for task that are needed to do task

2.3.2.3.0.0. Identify physical skills to be acquired

2.3.2.3.1.0. Methods employed to identify physical skill reqrmnts of tasks

2.3.2.3.1.1. Aspects of methods that are irrel to id physical skills to do task

2.3.2.3.1.2. Aspects missing from methods essential to id phys skills reqd

2.3.2.3.1.3. Input data reqd for methods that are missing or insufficient

2.3.2.3.2.0. Physical skill requirements identified for BIFV gunner tasks

2.3.2.3.2.1. Physical skills id as reqd that are not reqd to do task

2.3.2.3.2.2. Phys skills id as reqd that are not reqd to do task
2.3.2.4.0.0. Identify attitudes to be acquired
2.3.2.4.1.0. Methods employed to identify the attitudinal requirements of tasks
2.3.2.4.1.1. Aspects of methods empld that are irrel to id of attitudes reqd
2.3.2.4.1.2. Aspects missing from methods empld that are essential to do task
2.3.2.4.1.3. Input data reqd for methods that are missing or insufficients
2.3.2.4.2.0. The attitudinal requirements identified for BIFV gunner tasks
2.3.2.4.2.1. Attitudinal elements id as reqd that are not reqd to do task
2.3.2.4.2.2. Attitudinal elements not id as reqd that are reqd to do task
2.3.3.0.0.0. Identify the conditions for learning the task
2.3.3.0.1.0. Methods employed to identify the conditions for lrng BIFVG tasks
2.3.3.0.1.1. Aspects/elements of methods employed that are irrel/inconsistent
2.3.3.0.1.2. Aspects/elements missing from methods essential to id lrng conds
2.3.3.0.1.3. Input data required for methods that are missing/insufficient
2.3.3.0.2.0. Types of conditions for lrng that are identified for ea BIFVG task
2.3.3.0.2.1. Types of conditions for lrng misidentified as assoc w/task
2.3.3.0.2.2. Types of conditions for lrng not id as assoc w/task that are
2.3.3.1.0.0. Analyze info procsng rqmts to idntfy prerequisite knwldg expected of learners
2.3.3.1.1.0. Methods employed to identify prerequisite knowledge for tasks
2.3.3.1.1.1. Aspects of the methods irrel to id knowledge prereq to lrn task
2.3.3.1.1.2. Aspects missing from methods empd that are essential to lrn task
2.3.3.1.1.3. Input data reqd for the methods that are missing or insufficient
2.3.3.1.2.0. Knowledge items identified as prerequisites for learning tasks
2.3.3.1.2.1. Knowledge items id as prereq to lrn task that are not necessary
2.3.3.1.2.2. Knowledge items not id as prereq for lrng task that are reqd
2.3.3.1.2.3. Knowledge items not id as prereq to lrn task that would help lrng
2.3.3.2.0.0. Analyze those requirements to identify prerequisite mental skills
2.3.3.2.1.0. Methods employed to identify prereq mental skills for tasks
2.3.3.2.1.1. Aspects of methods irrel to id of mental skills reqd to learn task
2.3.3.2.1.2. Aspects missing from methods reqd to id mental skills reqd to learn
2.3.3.2.1.3. Input data reqd for methods missing or insufficient
2.3.3.2.2.0. Specific mental skills identified as prereq for learning tasks
2.3.3.2.2.1. Mental skills id prerequisite to learn not needed to learn task
2.3.3.2.2.2. Mental skills not id prerequisite to learn essential to learn task
2.3.3.2.2.3. Mental skills not id as prereq that facilitate learning task
2.3.3.3.0.0. Analyze the physical requirements to identify prerequisite motor skills
2.3.3.3.1.0. Methods employed to identify prereq physicial skills for tasks
2.3.3.3.1.1. Aspects employed irrelevant to id of phys skills requisite to learn
2.3.3.3.1.2. Aspects missing that are essen to id phys skills requisite to lrng
2.3.3.3.1.3. Input data required for methods missing or insufficient

2.3.3.3.2.0. Specific physical skills identified as prereq for learning tasks
2.3.3.3.2.1. Phys skills id as prereq not needed for learning task
2.3.3.3.2.2. Phys skills not id as prereq essential for learning task
2.3.3.3.2.3. Phys skills not id prereq that facilitate learning task
2.3.3.4.0.0. Analyze the attitudinal requirements to identify prerequisite values
2.3.3.4.1.0. Methods employed to identify the prereq attitudes for tasks
2.3.3.4.1.1. Aspects of methods irrelevant to id of attitudinal prereq
2.3.3.4.1.2. Aspects of methods missing that are essen for id of attitud prereq
2.3.3.4.1.3. Input data required for methods that are missing/insufficient
2.3.3.4.2.0. Specific attitudes identified as prereq for learning tasks
2.3.3.4.2.1. Attitudes id prereq not needed to learn task
2.3.3.4.2.2. Attitudes not id as prereq that are essential for learning
2.3.3.4.2.3. Attitudes not id as prereq that facilitate learning task
2.4.0.0.0.0. Determine instructional requirements
2.4.1.0.0.0. Identify instructional events/activities required
2.4.1.1.0.0. Select types of events/actvts reqrd to prepare learners to learn various tasks
2.4.1.2.0.0. Select types of events/actvts required to present/demonstrate the tasks
2.4.1.3.0.0. Select types of events/actvts required for learners to practice/apply tasks
2.4.1.4.0.0. Select types of events/actvts required to evaluate learners' performance
2.4.2.0.0.0. Identify strategic instructional requirements
2.4.2.1.0.0. Analyze events/activities to establish their sequence
2.4.2.2.0.0. Analyze events/activities to establish their delivery media
2.4.3.0.0.0. Identify tactical instructional requirements
2.4.3.1.0.0. Analyze events/activities to establish their management procedures
2.4.3.2.0.0. Analyze events/activities to establish their resource requirements
2.4.4.0.0.0. Identify learner assessment requirements
2.4.4.1.0.0. Analyze tasks to identify assessment rqmts for selecting/accepting learners
2.4.4.2.0.0. Analyze tasks to identify assessment rqmts for providing remedial instruction
2.4.4.3.0.0. Anlz tasks to idntfy assmt rqmts for acclrtg/talrg lrnrs' prgs thru instrction
2.4.4.4.0.0. Anlz tsks to idntfy assmt rqmts for advncg/dlayg lrnrs' prgs thru instruction
2.4.4.5.0.0. Anlz tsks to idntfy assmt rqmts for crtfyg/dcrtfyg lrnrs' as job performers
2.5.0.0.0.0. Analyze existing instruction
2.5.1.0.0.0. Assess relevance and applicability of existing instruction to present rqmts
2.5.1.1.0.0. Specify criteria of relevance and applicability
2.5.1.2.0.0. Search for existing instruction of potential relevance and applicability
2.5.1.3.0.0. Access & review existing instruction of potential relevance and applicability
2.5.1.4.0.0. Rate relevance/applicability of instruction
2.5.1.5.0.0. Select existing instrctn warranting application to present instrctnl rqmts
2.5.2.0.0.0. Assess effectiveness/efficiency of existing instruction
2.5.2.1.0.0. Idntfy instrctnl events/actvts implmntd by tchnlgclly outmoded methds/media

2.5.2.2.0.0. Assess degree of inefficiency/ineffectiveness
2.5.2.3.0.0. Assess cost of replacing outmoded instruction
2.5.2.4.0.0. Formulate decision to use or replace existing instruction
2.6.0.0.0.0. Assemble instruction
2.6.1.0.0.0. Adapt relevant & applicable instruction to satisfy present instrctnl rqmts
2.6.1.1.0.0. Idntfy specfc deficiencies in the events/actvts of the applicable instruction
2.6.1.2.0.0. Dvlp spcfc chngs to evnts/actvts & thr prscrptns to remove the deficiencies
2.6.2.0.0.0. Create instruction, where necessary, to meet unsatisfied instructional rqmts
2.6.2.1.0.0. Identify specific objectives for which new instruction is needed
2.6.2.2.0.0. Anlz the objctvs to idntfy the instructional events/activities needed
2.6.2.3.0.0. Select implementing methods/media
2.6.2.4.0.0. Prepare detailed prescriptions of the methods and media
2.7.0.0.0.0. Conduct training trials
2.7.1.0.0.0. Guide the ongoing analysis and assembly of instruction
2.7.1.1.0.0. Apply small blocks of existing instruction to individual candidate learners
2.7.1.2.0.0. Apply small blocks of new instruction to individual candidate learners
2.7.1.3.0.0. Apply small blocks of assmbld instrctn to small groups of cndidate lrnrs
2.7.2.0.0.0. Verify the suitability of the assembled instruction for delivery
2.7.2.1.0.0. Conduct field testing of the assembled instruction
3.0.0.0.0.0. Products: The system must produce:
3.1.0.0.0.0. Documented job analyses
3.1.1.0.0.0. Provide complete specification of what constitutes the job to be trained
3.1.1.1.0.0. Specification of mental processes to the level of binary decisions
3.1.1.2.0.0. Specification of physical processes to the level of discrete actions
3.1.1.3.0.0. Specification of all process stimuli
3.1.1.4.0.0. Specifications of conditions under which processes are to take place
3.1.2.0.0.0. Provide complete specification of the organization of the job
3.1.2.1.0.0. Operational sequence diagrams
3.1.2.2.0.0. Decision flowcharts
3.1.2.3.0.0. Specification of rules and regulations
3.1.3.0.0.0. Provide complete specification of what constitutes job adequacy
3.1.3.1.0.0. Performance accuracy specification
3.1.3.2.0.0. Performance speed specification
3.1.3.3.0.0. Performance volume specification
3.1.3.4.0.0. Performance duration specification
3.2.0.0.0.0. Stated performance objectives
3.2.0.0.1.0. The BIFV gunner performance objectives that are stated
3.2.0.0.1.1. Stmnts defining perf obj not needed for BIFVG
3.2.0.0.1.2. Perfm obj needed for BIFVG not addressed in stmnts provided
3.2.0.0.2.0. The format of the statements of BIFV gunner performance objectives

3.2.0.0.2.1. Essntl elem of perf obj stmnts not in format stating BIFV perf obj
3.2.0.0.2.2. Inessntl elem in format used to state BIFV perf obj
3.2.0.0.3.0. The completeness of the statements of BIFVG performance objectives
3.2.0.0.3.1. Elements missing from stmnts of particular BIFV perf obj
3.2.0.0.4.0. The accuracy of the statements of BIFVG performance objectives
3.2.0.0.4.1. BIFV perf obj statements containing erroneous/inaccurate elements
3.2.0.0.4.2. Description of inaccuracies for each stated objective
3.2.1.0.0.0. Define exactly what learners are expected to achieve as result of training
3.2.1.0.1.0. BFIV gunner-learner achievements that are defined
3.2.1.0.1.1. Achievements not necessarily expected of BIFVG lrnrs in training
3.2.1.0.1.2. Achievements that are expected of BIFVG lrnrs in training
3.2.1.0.1.3. Inexact elements in definitions of BIFVG learner achievements
3.2.1.0.1.4. Inaccurate elements in definitions of BIFVG learner achievements
3.2.1.0.2.0. Factors in the definitions of BIFV gunner-learner achievements
3.2.1.0.2.1. Factors that are irrelevant to achievements of BIFVG learners
3.2.1.0.2.2. Factors missing and essential to describe achievements of BFIG lrnr
3.2.1.1.0.0. Specification of the basic capabilities the learners are to acquire
3.2.1.1.1.0. Capabilities specified for achievement by gunners/learners
3.2.1.1.1.1. Capabilities specified not relevant to achievement of BIFVG lrnrs
3.2.1.1.1.2. Capabilities not specified essential to achievements of BIFVG lrnrs
3.2.1.2.0.0. Specification of an observable action learners execute to show each capability
3.2.1.2.1.0. Actions specified for execution by BIFV gunner/learners
3.2.1.2.1.1. Specified actions that do not demonstrate intended capabilities
3.2.1.2.1.2. Actions not specified that would demonstrate intended capabilities
3.2.1.2.2.0. Observability of the specified actions
3.2.1.2.2.1. Reviewers' rating of observability of specified actions
3.2.1.2.2.2. Reqmts for constraining gunner-lrnr execution to enhance obsvabilty
3.2.1.2.2.3. Reviewers' rating of how observation will impede gnr/lrnr execution
3.2.1.3.0.0. Specification of a measurable object that will result from the action
3.2.1.3.1.0. Objects specified as results of actions exec by gunner/learner
3.2.1.3.1.1. Specified objects that do not result from BIFVG-lrnr actions
3.2.1.3.1.2. Non-specified objects that do result from BIFVG-lrnr actions
3.2.1.3.1.3. Specified attributes that do not show achievement of capabilities
3.2.1.3.1.4. Non-specified attributes that do show achievement of capabilities
3.2.1.3.2.0. Measurability of specified objects
3.2.1.3.2.1. Potential methods to directly measure relevant attributes
3.2.1.3.2.2. Potential methods to indirectly measure relevant attributes
3.2.1.3.2.3. Probable distribution of measurement error for each method
3.2.1.4.0.0. Specification of conditions in which learners will execute the action
3.2.1.4.1.0. Circumstances specified for execution of actions by gunner/learners

3.2.1.4.1.1. Specified factors not applying under realistic job conditions
3.2.1.4.1.2. Non-specified factors applying under realistic job conditions
3.2.1.4.1.3. Deviations in value, ranges & limits under real job conditions
3.2.1.5.0.0. Specification of any tools or equipment the learners will use to execute action
3.2.1.5.1.0. Tools and equip specified in executing gunner/learners' actions
3.2.1.5.1.1. Specified tools/equipment not available under real job conditions
3.2.1.5.1.2. Non-specified tools/equipment available under real job conditions
3.2.1.6.0.0. Specification of any constraints imposed upon learners' execution of the action
3.2.1.6.1.0. Constraints specified for exec of gunner/learners' actions
3.2.1.6.1.1. Specified constrained behavior not constrained under real job cond
3.2.1.6.1.2. Non-specified constrained behavior constrained under real job cond
3.2.1.6.1.3. Deviations between degree of constraints specified vs actual
3.2.1.7.0.0. Specification of criteria the product must satisfy to show achievement of task
3.2.1.7.1.0. Criteria specified as standards of adequancy for objects
3.2.1.7.1.1. Deviations in criteria specified vs stds required for adequate perf
3.2.2.0.0.0. Provide an organization framework for the training
3.2.2.1.0.0. Specification of essential abilities included within each performance objective
3.2.2.2.0.0. Specification of supportive abilities in instruction for each objective
3.2.2.3.0.0. Specification of sequence of instruction to be prepared for each objective
3.2.2.4.0.0. Specification of the sequence of objectives to be followed in the instruction
3.3.0.0.0.0. Lesson plans
3.3.1.0.0.0. Provide complete specification of the instructional content for each objective
3.3.1.1.0.0. Specification of the objective
3.3.1.2.0.0. Specification of assumed learner prerequisites
3.3.1.3.0.0. Itemization of information topics
3.3.1.4.0.0. Itemization of mental skills steps
3.3.1.5.0.0. Itemization of physical skills steps
3.3.1.6.0.0. Itemization of attitudinal components
3.3.1.7.0.0. Itemization of practice exercises
3.3.1.8.0.0. Itemization of test problems/exercises
3.3.2.0.0.0. Provide complete spec of instructional procedures for each objective
3.3.2.1.0.0. Specification of procedures for preparing learners to achieve the objective
3.3.2.2.0.0. Specification of how the instructional content topics/steps will be presented
3.3.2.3.0.0. Specification of how the learners will practice/apply the instructional content
3.3.2.4.0.0. Specification of how the learners will be tested on the instructional content
3.3.2.5.0.0. Specification of how to deal with those who fail to show objective achieved
3.3.3.0.0.0. Provide complete spec of instructional circumstances for each objective
3.3.3.1.0.0. Specification of location at which each instructional event will take place
3.3.3.2.0.0. Specification of the equipment needed
3.3.3.3.0.0. Specification of special location/equipment set-up configuration requirements

3.3.3.4.0.0. Specification of instructional personnel needed
3.3.3.5.0.0. Specification of time and schedule requirements
3.4.0.0.0.0. Training documents
3.4.1.0.0.0. Provide essential resources to learners
3.4.1.1.0.0. Texts
3.4.1.2.0.0. Workbooks
3.4.1.3.0.0. Study guides
3.4.1.4.0.0. Lists of references
3.4.1.5.0.0. Schedule of instruction
3.4.2.0.0.0. Provide essential guidance to facilitators
3.4.2.1.0.0. Sets of lesson plans
3.4.2.2.0.0. Sets of test specifications
3.4.2.3.0.0. Lists of facilitator references
3.4.2.4.0.0. Specifications of facilitator prerequisites
3.4.3.0.0.0. Provide essential specifications to facilities developers
3.4.3.1.0.0. Specifications of physical requirements for instructional sites
3.4.3.2.0.0. Specifications for audiovisuals
3.4.3.3.0.0. Specifications for training equipment and supplies
3.4.4.0.0.0. Provide essential support to training system administrators
3.4.4.1.0.0. Detailed outline of instructional objectives, content, procedures, & schedule
3.4.4.2.0.0. Specifications of learner prerequisites
3.4.4.3.0.0. Summaries of personnel requirements
3.4.4.4.0.0. Summaries of facilities requirements
3.4.4.5.0.0. Documentation of all activities during the process
3.5.0.0.0.0. Tests
3.5.0.0.1.0. BIFV gunner-learner tests that are prepared
3.5.0.0.1.1. Prepared tests that address each BIFVG performance objective
3.5.0.0.1.2. Prepared tests that relate to no BIFVG performance objective
3.5.0.0.2.0. BIFV gunnery testing applic/reqmts for which tests are prepared
3.5.0.0.2.1. Reviewers' ratings of utility of each test for each test/applic req
3.5.0.0.3.0. BIFV gunner behaviors for which tests are prepared
3.5.0.0.3.1. Listing of tests prepared for ea behavior assoc w/ ea perfm objctv
3.5.0.0.4.0. Relevance of the tests
3.5.0.0.4.1. Deviations between behav elicited by tests and behav to be studied
3.5.1.0.0.0. Acquire qualified candidate learners
3.5.1.0.1.0. Candidate gunner-learner qual for which tests are prepared
3.5.1.0.1.1. Relevant qualifications for which tests are prepared
3.5.1.0.1.2. Relevant qualifications for which no tests are prepared
3.5.1.0.1.3. Irrelevant 'qualifications' for which tests are prepared
3.5.1.0.2.0. The tests prepared for assessment of the qualifications

3.5.1.0.2.1. Elements of ea test that deviate from qual actually required
3.5.1.0.2.2. Probability that ea test will be passed by unqualified candidate
3.5.1.0.2.3. Probability that ea test will be failed by qualified candidate
3.5.1.0.2.4. Cum prob that unqual candidate passes critical # tests to be cand
3.5.1.0.2.5. Cum prob that qual candidate fails critical # tests to be rejected
3.5.1.1.0.0. Measures of prerequisite abilities
3.5.1.1.1.0. Domains of learning addressed by the tests
3.5.1.1.1.1. Qual tests that test only irrelevant materials
3.5.1.1.1.2. Qual tests that test both relevant & irrelevant materials
3.5.1.1.2.0. Actions elicited by the tests
3.5.1.1.2.1. Deviations between tests and actual learning requirements
3.5.1.1.2.2. Probability that exec of elicited action implies can exec action
3.5.1.1.2.3. Probability that failure to exec elicited actn implies cannot do it
3.5.1.1.3.0. Objects intended to result from actions elicited by tests
3.5.1.1.3.1. Deviations between objects to result from tests vs reqd actions
3.5.1.1.3.2. Prob production of test object implies ability to prod reqd object
3.5.1.1.3.3. Prob failure to prod test object implies inability to prod rqd obj
3.5.1.2.0.0. Measures of application procedures
3.5.1.2.1.0. Circumstances specified for the tests
3.5.1.2.1.1. Deviation between circum under which tests vs action are run
3.5.1.2.1.2. Prob passing test under test conds implies ability to apply qualif
3.5.1.2.1.3. Prob that failing test in test environ implies inability to train
3.5.1.2.2.0. Tools and equipment specified for the tests
3.5.1.2.2.1. Deviations between tools/equip used in testing vs training
3.5.1.2.2.2. Prob that passing test w/test tools implies can use training tools
3.5.1.2.2.3. Prob that failing test w/test tools implies cant use trng tools
3.5.1.2.3.0. Constraints specified for the tests
3.5.1.2.3.1. Deviations between test vs training constraints
3.5.1.2.3.2. Prob passing test w/test constraints implies can do w/trng cnstrnts
3.5.1.2.3.3. Prob fail test w/test constraints implies cannot do w/trng cnstrnts
3.5.1.3.0.0. Standards of candidate qualification
3.5.1.3.1.0. Standards specified for the qualification tests
3.5.1.3.1.1. Deviation between test standards & actual training standards
3.5.1.3.1.2. Probability that satisf of test stds implies abil to do trng stds
3.5.1.3.1.3. Prob that fail to satisfy test std implies inability to do trng std
3.5.1.4.0.0. Specifications for dealing with substandard candidates
3.5.2.0.0.0. Tailor instruction to learners
3.5.2.0.1.0. BIFV Gunnery abilities for which tailored tests are prepared
3.5.2.0.1.1. Relevant gunnery abilities for which tests are prepared
3.5.2.0.1.2. Relevant gunnery abilities for which no tests are prepared

3.5.2.0.1.3. Irrelevant 'abilities' for which tests are prepared
3.5.2.0.2.0. The tests to assess need to tailor instruction to fit lrnrs ability
3.5.2.0.2.1. Elements of ea test that deviate from abilities reqd of BIFVG
3.5.2.0.2.2. Prob ea test will be passed by lrnrs who should not
3.5.2.0.2.3. Prob ea test will be failed by lrnrs who posess abilty being tested
3.5.2.0.2.4. Cum prob lrnr's test perform will result in inappropriate instruct.
3.5.2.1.0.0. Pre-training measures of intended abilities
3.5.2.1.1.0. Domains of learning addressed by the tests
3.5.2.1.1.1. Tailoring tests that test only irrelevant abilities
3.5.2.1.1.2. Tailoring tests that test relevant & irrelevant abilities
3.5.2.1.2.0. Actions elicited by the tests
3.5.2.1.2.1. Deviations between actions elic by test & actions reqd for task
3.5.2.1.2.2. Prob that exec of elicited action implies lrnr can exec reqd action
3.5.2.1.2.3. Prob that failure to exec elicited action implies lrnr can't do it
3.5.2.1.3.0. Objects intended to result from the actions elicited by tests
3.5.2.1.3.1. Deviations between objects resulting from tests vs reqd actions
3.5.2.1.3.2. Prob that prod of test object implies ability to produce reqd obj
3.5.2.1.3.3. Prob that failure to prod test obj implies can't prod reqd object
3.5.2.2.0.0. Measures application procedures
3.5.2.2.1.0. Circumstances specified for the tests
3.5.2.2.1.1. Deviations between specified vs actual circumstances
3.5.2.2.1.2. Probability that passing test implies lrnr can apply in real job
3.5.2.2.1.3. Probability that failing test implies lrnr cannot apply in real job
3.5.2.2.2.0. Tools and equipment specified for the tests
3.5.2.2.2.1. Deviations between tools/equip specified vs those used by BIFVG
3.5.2.2.2.2. Probability that passing test implies lrnr can apply gunnery abilty
3.5.2.2.2.3. Probability that failing test implies lrnr cannot apply ability
3.5.2.2.3.0. Constraints specified for the tests
3.5.2.2.3.1. Deviations between constraints specified vs actual on the job
3.5.2.2.3.2. Probability that passing implies lrnr can apply ability on the job
3.5.2.2.3.3. Probability that failing implies lrnr cannot apply ability on job
3.5.2.3.C.0. Standards of pre-training qualification
3.5.2.3.1.0. Standards specified for the tailoring tests
3.5.2.3.1.1. Deviations between specified standards vs actual on the job
3.5.2.3.1.2. Probability that satisfying standards implies adequate job perf
3.5.2.3.1.3. Probability that not satisfying stds implies inadequate job perf
3.5.2.4.0.0. Specification of procedures for dealing with qualified learners
3.5.3.0.0.0. Measure learner's achievements
3.5.3.0.1.0. Gunner-learner achievements for which tests are prepared
3.5.3.0.1.1. Relevant achievements for which tests are prepared

3.5.3.0.1.2. Relevant achievements for which no tests are prepared
3.5.3.0.1.3. Irrelevant 'achievements' for which tests are prepared
3.5.3.0.2.0. Tests prepared for assessment of BIFV gunner-learners' achievements
3.5.3.0.2.1. Elements the deviate from achievements actually reqd of BIFVGs
3.5.3.0.2.2. Probability that test is passed by lrnrs not possessing achievement
3.5.3.0.2.3. Probability that test is not passed by lrnrs possessing achievement
3.5.3.0.2.4. Cumulative probability that unqualified lrnr will pass for certific
3.5.3.0.2.5. Cumulative probability that qualified lrnr will fail & be rejected
3.5.3.1.0.0. Post-training measures of intended abilities
3.5.3.1.1.0. Domains of learning addressed by the tests
3.5.3.1.1.1. Achievement tests that measure only irrelevant items
3.5.3.1.1.2. Achievement tests that measure relevant and irrelevant items
3.5.3.1.2.0. Actions elicited by the tests
3.5.3.1.2.1. Deviations between actions tested vs reqd for each achievement
3.5.3.1.2.2. Probability that passing test implies ability to demo achievement
3.5.3.1.2.3. Probability that failing test implies inability to demo achievement
3.5.3.1.3.0. Objects intended to result from actions elicited by tests
3.5.3.1.3.1. Deviations between objs resulting from tested vs required actions
3.5.3.1.3.2. Probability that producing test object implies producing actual obj
3.5.3.1.3.3. Probability failing to prod test obj implies fail to prod real obj
3.5.3.2.0.0. Measures application procedures
3.5.3.2.1.0. Circumstances specified for the tests
3.5.3.2.1.1. Deviations between circumstances for test vs actual on the job
3.5.3.2.1.2. Probability passing test implies ability to do job
3.5.3.2.1.3. Probability that failing test implies inability to do job
3.5.3.2.2.0. Tools and equipment specified for the tests
3.5.3.2.2.1. Deviations between tools/equipment on training vs job
3.5.3.2.2.2. Probability of passing test indicates ability to use job tools
3.5.3.2.2.3. Probability of failing test indicates inability to use job toos
3.5.3.2.3.0. Constraints specified for the tests
3.5.3.2.3.1. Deviations between constraints vs actual job application
3.5.3.2.3.2. Probability passing test w/constraints implies ability on the job
3.5.3.2.3.3. Probability failing test w/constraints implies inability on the job
3.5.3.3.0.0. Standards of post-training qualification
3.5.3.3.1.0. Standards specified for the achievement tests
3.5.3.3.1.1. Deviations between test standards vs job standards
3.5.3.3.1.2. Probability passing test implies adequate performance on the job
3.5.3.3.1.3. Probability failing test implies inadequate performance on the job
3.5.3.4.0.0. Specification of procedures for dealing with unqualified learners
3.6.0.0.0.0. Training trial data

3.6.1.0.0.0. Provide justification for specific features of instructional design
3.6.1.1.0.0. Entry test data derived from representative candidate learners
3.6.1.2.0.0. Post-test data derived from representative job incumbents
3.6.1.3.0.0. Test item error analysis derived from tryout learners
3.6.1.4.0.0. Instruction design feedback data obtained from tryout learners and facilitators
3.6.1.5.0.0. Specification of revisions based on these data
3.6.2.0.0.0. Demonstrate validity and utility of the training
3.6.2.1.0.0. Test item error analyses derived from field test learners
3.6.2.2.0.0. Correlations between learners' post-test results and subsequent job performance
3.6.2.3.0.0. Instruction design feedback obtained from field test learners and facilitators
3.6.2.4.0.0. Specification of final revisions based upon these data
4.0.0.0.0.0. Environment: Performance objectives must be met despite:
4.1.0.0.0.0. Operation in tropical environments
4.1.1.0.0.0. High temperature and humidity
4.1.1.1.0.0. Temperatures up to 140 deg F/60 deg C
5.0.0.0.0.0. Constraints: Performance objectives must be met despite:
5.1.0.0.0.0. Adherence to NATO - compatible specifications
5.1.1.0.0.0. Use of metric-calibrated scales
5.1.1.1.0.0. Absence of operator training or prior experience with the metric system

APPENDIX B

Training Enabling Subsystem Data Base

Final Summary Report
February 28, 1983
Illustration of Enabling Subsystem

Measurement Purpose: Global

System Class: Training[4]
System: Bradley Infantry Fighting Vehicle Training System (BIFVTS)[1]
Subsystem: Enabling[5]

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1.0.0.0.0.0. Potentialities: The system must be capable of:
    1.1.0.0.0.0. Providing day-to-day training management resources
      1.1.1.0.0.0. Establishing a schedule of learning activities
        1.1.1.1.0.0. Identifying scheduling options
        1.1.1.2.0.0. Devising schedule monitoring mechanisms
        1.1.1.3.0.0. Devising schedule control mechanisms
      1.1.2.0.0.0. Establishing a conducive learning climate
        1.1.2.1.0.0. Encouraging maximum learner participation
        1.1.2.2.0.0. Eliciting sense of responsibility for learning from learners
        1.1.2.3.0.0. Treating learners with respect
        1.1.2.4.0.0. Encouraging learners' freedom of expression
        1.1.2.5.0.0. Avoiding disorder and learning distaste
      1.1.3.0.0.0. Monitoring and modifying the learning experience
        1.1.3.1.0.0. Measuring learners' progress
        1.1.3.2.0.0. Diagnosing emerging deficiencies and difficulties in learning
        1.1.3.3.0.0. Simplifying key operative information
        1.1.3.4.0.0. Tailoring learning activities to specific experiences of learners
        1.1.3.5.0.0. Tailoring schedule and sequence of learning to learners' capabilities and needs
      1.1.4.0.0.0. Operating the training facilities and equipment
        1.1.4.1.0.0. Developing skills in the use of relevant instructional aids
        1.1.4.2.0.0. Developing skills in the appropriate control of the physical environment
        1.1.4.3.0.0. Developing skills in the preparation of relevant special facilities & equipment
      1.1.5.0.0.0. Implementing learning activities
        1.1.5.1.0.0. Preparing learners to learn
        1.1.5.2.0.0. Presenting learning content to learners
        1.1.5.3.0.0. Guiding learners' application of learning
        1.1.5.4.0.0. Testing learners' achievement of learning
      1.1.6.0.0.0. Acquiring and disseminating  learning resources
        1.1.6.1.0.0. Assembling learning-relevant experiences
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1.1.6.2.0.0. Acquiring and/or fabricating resource materials
1.2.0.0.0.0. Insuring availability of instructional delivery expertise
1.2.1.0.0.0. Conveying learning stimuli
1.2.1.1.0.0. Informing learners of the learning objectives
1.2.1.2.0.0. Relating objectives to learners' own needs
1.2.1.3.0.0. Relating objectives to learners' own experiences
1.2.2.0.0.0. Presenting information
1.2.2.1.0.0. Gearing presentations to learners' abilities and achievements
1.2.2.2.0.0. Selecting meaningful images, patterns, etc. to vivify content
1.2.2.3.0.0. Utilizing multiple senses to reinforce learning
1.2.2.4.0.0. Involving learners actively in the presentation
1.2.3.0.0.0. Demonstrating procedures
1.2.3.1.0.0. Exposing each step in the procedure
1.2.3.2.0.0. Clarifying the purpose for each step
1.2.3.3.0.0. Manifesting performance technique
1.2.3.4.0.0. Involving learners actively in the demonstration
1.2.4.0.0.0. Conducting learner practice
1.2.4.1.0.0. Selecting and creating opportunities for practice
1.2.4.2.0.0. Involving learners actively in practice
1.2.4.3.0.0. Sequencing practice experiences to enhance learning development
1.2.4.4.0.0. Developing and maintaining realism in practice
1.2.4.5.0.0. Observing and tutoring learners in practice
1.2.4.6.0.0. Helping learners sense progress towards learning objectives and goals
1.2.5.0.0.0. Conducting learner tests
1.2.5.1.0.0. Diagnosing specific needs for learning
1.2.5.2.0.0. Diagnosing learners' progress
1.2.5.3.0.0. Diagnosing deficiencies in the learning environment
1.3.0.0.0.0. Insuring availability of learning guidance expertise
1.3.1.0.0.0. Motivating learners to learn
1.3.1.1.0.0. Clarifying the value of learning to the learners
1.3.1.2.0.0. Demonstrating enthusiasm
1.3.1.3.0.0. Encouraging learners' aspirations and initiatives
1.3.1.4.0.0. Rewarding learners' progress and participation
1.3.1.5.0.0. Demonstrating patience and compassion
1.3.2.0.0.0. Focusing learners' attention and interest
1.3.2.1.0.0. Creating situations and learning activities that are inherently interesting
1.3.2.2.0.0. Conveying a sense of excitement
1.3.2.3.0.0. Dramatizing for emphasis and reinforcement
1.3.2.4.0.0. Sensing and responding to learners' attention and interest
1.3.3.0.0.0. Relating the learning to the learners' experience

1.3.3.1.0.0. Exploiting learners' experiences through discussions, case-studies, role-play...
1.3.3.2.0.0. Emphasizing immediacy of application of learning to learner-relevant needs
1.3.4.0.0.0. Coaching learners
1.3.4.1.0.0. Raising and maintaining learners' level of aspiration for achievement
1.3.4.2.0.0. Mediating and facilitating the transfer from training to operations
1.3.4.3.0.0. Serving as a mentor to extend and control learners' talent
1.3.4.4.0.0. Prompting and cuing learners, when necessary
1.3.5.0.0.0. Feeding-back to learners
1.3.5.1.0.0. Conveying diagnoses of learners' performance to learners
1.3.5.2.0.0. Positively reinforcing desirable performance
1.3.5.3.0.0. Constructively criticizing deficient performance
1.3.6.0.0.0. Facilitating learner self-assessment
1.3.6.1.0.0. Assisting learners to develop and apply self-evaluation procedures
1.3.6.2.0.0. Assisting learners to diagnose their own needs for learning
1.3.6.3.0.0. Assisting learners to translate diagnosed needs into specific objectives
1.3.7.0.0.0. Counseling learners
1.3.7.1.0.0. Assisting learners to plan and organize their learning activities
1.3.7.2.0.0. Assisting learners to implement their learning activities
1.3.7.3.0.0. Assisting learners in dealing with problems affecting their learning
1.3.7.4.0.0. Interacting with lrnrs to raise morale/aspirations as motivation & efforts fall
1.4.0.0.0.0. Insuring availability of subject matter expertise
1.4.1.0.0.0. Knowing the ingredients of that which is to be learned
1.4.1.1.0.0. Knowing the elements of the cognitive aspects of the training
1.4.1.2.0.0. Knowing the elements of the psychomotor aspects of the training
1.4.1.3.0.0. Knowing the elements of the affective aspects of the training
1.4.2.0.0.0. Performing/demonstrating that which is to be learned
1.4.2.1.0.0. Demonstrating and articulating the cognitive tasks of the job
1.4.2.2.0.0. Demonstrating and articulating the psychomotor tasks of the job
1.4.2.3.0.0. Demonstrating and articulating the attitudes required of the job
1.4.3.0.0.0. Citing illustrative examples to assist learning
1.4.3.1.0.0. Relating practical applications of the intended lrng by role-model performers
1.4.3.2.0.0. Relating beneficial learning experiences used by previous learners
1.4.3.3.0.0. Facilitating interchange of relevant experiences of current learners
1.5.0.0.0.0. Familiarizing facilitators with the curriculum
1.5.1.0.0.0. Knowing what learners are intended to achieve
1.5.1.1.0.0. Understanding the intended goals of learning
1.5.1.2.0.0. Understanding the intended performance objectives
1.5.1.3.0.0. Understanding the prerequisite abilities expected of learners
1.5.2.0.0.0. Knowing the training content
1.5.2.1.0.0. Understanding the topics to be covered

1.5.2.2.0.0. Understanding the associations among topics and performance objectives
1.5.2.3.0.0. Understanding the organization of the content's topical sequence
1.5.3.0.0.0. Knowing the training resources
1.5.3.1.0.0. Understanding the personnel resources available & needed
1.5.3.2.0.0. Understanding the equipment resources available and needed
1.5.3.3.0.0. Understanding the material/media resources available and needed
1.5.3.4.0.0. Understanding the facilities resources available and needed
1.5.4.0.0.0. Knowing the training procedures and methods
1.5.4.1.0.0. Understanding the preparation activities and procedures to be used
1.5.4.2.0.0. Understanding the presentation activities and procedures to be used
1.5.4.3.0.0. Understanding the application procedures and activities to be used
1.5.4.4.0.0. Understanding the evaluation activities and procedures to be used
1.5.5.0.0.0. Knowing the training circumstances
1.5.5.1.0.0. Understanding what conditions are to be controlled during learning activities
1.5.5.2.0.0. Understanding how to control these conditions
1.6.0.0.0.0. Tailoring the curriculum to specific delivery applications
1.6.1.0.0.0. Adapting the curriculum to the facilitator's style and strengths
1.6.1.1.0.0. Capitalizing on facilitators experiences that are relevant to intended learning
1.6.1.2.0.0. Selecting learning activities that are compatible with instructors skills
1.6.1.3.0.0. Developing procedural details to enhance facilitator's delivery of instruction
1.6.1.4.0.0. Acquiring and/or refining materials to enhance facilitators' delivery of instruc
1.6.2.0.0.0. Adapting the curriculum to specific lrning needs of a given delivery application
1.6.2.1.0.0. Deleting objectives that are not relevant to learning needs of a given applic
1.6.2.2.0.0. Defining new objectives relevant to learning needs of a given application
1.6.2.3.0.0. Modifying content to reflect changed objectives
1.6.2.4.0.0. Modifying resources to reflect changed objectives
1.6.2.5.0.0. Modifying procedures and methods to reflect changed objectives
1.6.2.6.0.0. Modifying conditions to reflect changed objectives
1.6.3.0.0.0. Adapting the curriculum to specific constraints of a given delivery application
1.6.3.1.0.0. Modifying resources to reflect specific constraints
1.6.3.2.0.0. Modifying procedures and methods to reflect specific constraints
1.6.3.3.0.0. Modifying conditions to reflect specific constraints
2.0.0.0.0.0. Processes: The system must carry out the following activities:
2.1.0.0.0.0. Analyze facilitator's ability to perform the tasks
2.1.1.0.0.0. Identify tasks for which a given prospect could credibly serve as a facilitator
2.1.1.1.0.0. Assess prospect's experiential history with respect to the tasks
2.1.1.2.0.0. Assess prospects training with respect to the tasks
2.1.1.3.0.0. Assess deg to which prospect manifests qualities/characteristics of good perfrmr
2.1.2.0.0.0. Identify deficiencies that could be corrected thru cost-effective training
2.1.2.1.0.0. Test the prospects ability to satisfy perfm objectives associated with each task

2.1.2.2.0.0. Estimate cost of training necessary to achieve satisfaction of perfm objectives
2.1.2.3.0.0. Formulate decisions to provide/not provide task perform trng for each prospect
2.2.0.0.0.0. Analyze facilitator's ability to manage/implement the learning activities
2.2.1.0.0.0. Identify learning activities which a prospect could credibly manage/implement
2.2.1.1.0.0. Assess prospect's experiential history managing/implementing lrng activities
2.2.1.2.0.0. Assess prospect's prior training relative to those types of learning activities
2.2.1.3.0.0. Assess prospect's qualities/characteristics to be good mgr/implementer of lrng
2.2.2.0.0.0. Identify deficiencies which could be corrected thru cost-effective training
2.2.2.1.0.0. Test prospect's ability to manage/implement lrng activity in question
2.2.2.2.0.0. Estimate cost of training to prepare prospect to manage/implement each activity
2.2.2.3.0.0. Formulate decisions re providing facilitator training for each prospect
2.3.0.0.0.0. Design activities to correct facilitator's deficiencies
2.3.1.0.0.0. Devise plans to insure achieving requisite levels of job performance skills
2.3.1.1.0.0. Identify specific perfm obj for which job performance training is needed
2.3.1.2.0.0. Analyze obj to id the learning events/activities needed
2.3.1.3.0.0. Select implementing method/media
2.3.1.4.0.0. Prepare/assemble detailed prescriptions of the methods and media
2.3.2.0.0.0. Devise plans to insure achieving requisite levels of instructional skills
2.3.2.1.0.0. Identify specific perfm obj for which facilitator training is needed
2.3.2.2.0.0. Analyze the objectives to identify the learning events/activities needed
2.3.2.3.0.0. Select implementing methods/media
2.3.2.4.0.0. Prepare/assemble detailed prescriptions of the methods and media
2.4.0.0.0.0. Design activities to allow adaptation of the curriculum
2.4.1.0.0.0. Devise plans to insure each facilitator learns curr. & instructional requirements
2.4.1.1.0.0. Id specific perform obj re familiarity with curriculum & instructional reqmts
2.4.1.2.0.0. Analyze objectives to id learning events/activities needed
2.4.1.3.0.0. Select implementing methods/media
2.4.1.4.0.0. Prepare/assemble detailed prescriptions of the methods and media
2.4.2.0.0.0. Devise plans to insure facilitator learns requirements of delivery application
2.4.2.1.0.0. Id specific perfm obj re familiarity with requirements of given dlvry applica
2.4.2.2.0.0. Analyze objectives to id the learning events/activities needed
2.4.2.3.0.0. Select implementing methods/media
2.4.2.4.0.0. Prepare/assemble detailed prescriptions of the methods and media
2.4.3.0.0.0. Devise plans to insure that facilitator develops addl details of procdrs & matls
2.4.3.1.0.0. Identify specific performance objectives re developing additional details
2.4.3.2.0.0. Analyze the objectives to id learning events/activities needed
2.4.3.3.0.0. Select implementing methods/media
2.4.3.4.0.0. Prepare/assemble detailed prescriptions of the methods and media
2.5.0.0.0.0. Conduct the facilitator's learning activities
2.5.1.0.0.0. Facilitators demonstrate satsfactory levels of job performance skills

2.5.1.1.0.0. Implement activities to prepare facilitators to achieve nweded Job skills
2.5.1.2.0.0. Implement activities to present/demonstrate skills to facilitators
2.5.1.3.0.0. Implement activities to insure that facilitators practice the skills
2.5.1.4.0.0. Implement activities to test facilitators achievement of Job perfm skills
2.5.2.0.0.0. Facilitators demonstrate satisfactory levels of instructional skills
2.5.2.1.0.0. Implement activities to prepare facilitators to achieve learning facilit. skills
2.5.2.2.0.0. Implement activities to present/demonstrate the skills to the facilitators
2.5.2.3.0.0. Implement activities to insure that facilitators practice the skills
2.5.2.4.0.0. Implement activities to test facilitators' achievement of facilitation skills
2.5.3.0.0.0. Facilitators demonstrate satisfactory ability to implement curr for dlvry applic
2.5.3.1.0.0. Implement activities to prepare facilitators to achieve curr implement abilities
2.5.3.2.0.0. Implement activities to present/demonstrate the abilities to the facilitators
2.5.3.3.0.0. Implement activities to insure that facilitators apply curr implent abilities
2.5.3.4.0.0. Implement activities to test facilitators curr implementation abilities
3.0.0.0.0.0. Products: The system must produce:
3.1.0.0.0.0. Qualified facilitators for given delivery applications
3.1.1.0.0.0. Facilitators able to help create a rich learning environment for the learners
3.1.1.1.0.0. Facilitators knowledgeable of the ingredients of the learning objective
3.1.1.2.0.0. Role-model performers of the ingredients
3.1.1.3.0.0. Facilitators knowlegeable of activities that can support achvmt of lrng objctvs
3.1.1.4.0.0. Insurers of the adequacy of the physical learning environment
3.1.1.5.0.0. Insurers of the availability of needed materials and resources
3.1.1.6.0.0. Communicators of interest and enthusiasm for the learning
3.1.1.7.0.0. Facilitators who are respectful of learners
3.1.1.8.0.0. Facilitators who are accepting of learners' needs and differences
3.1.1.9.0.0. Facilitators who are supportive & encouraging of learners' initiatives
3.1.1.10.0.0. Facilitators who are accessible to learners
3.1.2.0.0.0. Facilitators able to guide learners' interactions with the environment
3.1.2.1.0.0. Elicitors of learners' participation in the learning planning process
3.1.2.2.0.0. Creators of conditions to enhance desire for learning
3.1.2.3.0.0. Diagnosticians of learning needs
3.1.2.4.0.0. Creators of experience to enhance learning
3.1.2.5.0.0. Counselors of learners
3.1.2.6.0.0. Boosters of learners' aspirations and efforts
3.1.2.7.0.0. Managers of media to aid the learning process
3.1.2.8.0.0. Deliverers of information
3.1.2.9.0.0. Coaches of learners
3.1.2.10.0.0. Evaluators of learners' progress
3.2.0.0.0.0. Curricula tailored to given delivery applications
3.2.1.0.0.0. Curricula relevant to the learning needs of the given learners

3.2.1.1.0.0. Performance objectives specs stated in terms relevant to learners' needs
3.2.1.2.0.0. Plans for learning activities/experiences in accordance with given lrnrs needs
3.2.1.3.0.0. Presentations, applications, & tests consistent w/ lrnrs intended applic of lrng
3.2.1.4.0.0. Complete sets of refinements & details to implement curriculum per lrnrs needs
3.2.2.0.0.0. Curricula geared toward the experiences of given learners
3.2.2.1.0.0. Performance prerequisite specs stated in terms relevant to lrnr's experiences
3.2.2.2.0.0. Plans for lrng activities/experiences that draw upon given lrnr's experiences
3.2.2.3.0.0. Presentations & applications that make use of the given learners experiences

APPENDIX C

Training Delivery Subsystem Data Base

Final Summary Report
February 28, 1983
Illustration of Delivery Subsystem

Measurement Purpose: Global

System Class: Training[4]
System: Bradley Infantry Fighting Vehicle Training System (BIFVTS)[1]
Subsystem: Delivery[2]

1.0.0.0.0.0. Potentialities: The system must be capable of:
- 1.1.0.0.0.0. Providing learners with the learning environment
  - 1.1.1.0.0.0. Providing lrnrs with access to materials associated with lrng activities
    - 1.1.1.1.0.0. Identifying the learning materials to the learners
    - 1.1.1.2.0.0. Acquainting learners with use of the materials
    - 1.1.1.3.0.0. Distributing materials to the learners
  - 1.1.2.0.0.0. Providing lrnrs with access to the procedures associated with lrng activities
    - 1.1.2.1.0.0. Identifying the learning procedures to the learners
    - 1.1.2.2.0.0. Acquainting learners with implementation of procedures
  - 1.1.3.0.0.0. Providing lrnrs with access to the personnel associated with lrng activities
    - 1.1.3.1.0.0. Identifying the learning personnel to the learners
    - 1.1.3.2.0.0. Acquainting learners with roles of personnel in the learning
    - 1.1.3.3.0.0. Providing learners with media for accessing the personnel
  - 1.1.4.0.0.0. Providing access to the situation in which lrnrs may engage in lrng activities
    - 1.1.4.1.0.0. Allocating time for learners to engage in learning activities
    - 1.1.4.2.0.0. Removing distractions/impediments that would compete for lrnrs attention
- 1.2.0.0.0.0. Insuring Learners' interaction with the environment
  - 1.2.1.0.0.0. Insuring that learners engage in intended learning activities
    - 1.2.1.1.0.0. Insuring that learners use learning material in intended fashion
    - 1.2.1.2.0.0. Insuring that learners interact with lrng actvity personnel in intended fashn
    - 1.2.1.3.0.0. Insuring that lrnrs implement lrng activity procedures in intended fashion
  - 1.2.2.0.0.0. Insuring that the intended behaviors of learners are affected
    - 1.2.2.1.0.0. Monitoring effects on learners' behaviors
    - 1.2.2.2.0.0. Adjusting learning activities in response to monitored behaviors
- 1.3.0.0.0.0. Managing learners' progress
  - 1.3.1.0.0.0. Correcting deficiencies in learners' achievements
    - 1.3.1.1.0.0. Extending learning activities to enhance achievement
    - 1.3.1.2.0.0. Providing additional learning activities to enhance achievement
  - 1.3.2.0.0.0. Maximizing the efficiency of learners' learning activities

1.3.2.1.0.0. Selecting learning activities that most efficiently support learning by lrnrs
1.3.2.2.0.0. Providing a sequence of activities that most efficiently supports achievemnt
1.4.0.0.0.0. Evaluating learners' achievement
1.4.1.0.0.0. Determining learners' needs for remedial/qualification training
1.4.1.1.0.0. Testing lrnrs to determine their achievemnt of prerequisite perfmnc objectvs
1.4.1.2.0.0. Diagnos deficiencies to ID specific remedial training needs
1.4.2.0.0.0. Determining segments and objectives of lrng that are applicable to lrnrs
1.4.2.1.0.0. Pretesting learners to determine their achievement of inter & terminal perf obj
1.4.2.2.0.0. Diagnosing lrnr's pre-trng achievements to ID lrng obj & segmnts applic to lrnrs
1.4.3.0.0.0. Determining lrnrs' qualifications for advancemnt to intermediate lrng steps
1.4.3.1.0.0. In-course testing of lrnrs to determine achvment of intermediate performance obj
1.4.3.2.0.0. Diagnosing lrnrs' in-course achvmnts to assess preparedness for next sgmnts/objs
1.4.4.0.0.0. Determing lrnrs' qualifications for doing the job for which lrng was intended
1.4.4.1.0.0. Posttesting learners to determine their achievement of terminal performance obj
1.4.4.2.0.0. Diagnosing lrnrs' end-of-trng achvments to assess qual for certif as job perform
1.5.0.0.0.0. Providing bases for system evalution
1.5.1.0.0.0. Providing data re system's performance in satisfying lrng needs
1.5.1.1.0.0. Collecting data concerning lrnrs' achvmnts of established performance objectives
1.5.1.2.0.0. Collecting data concerning lrnr's perceptions of satisfaction of own lrng needs
1.5.2.0.0.0. Providing data re adequacy of support for trng dlvry from Command Subsystem
1.5.2.1.0.0. Collecting data concerning qualification of lrnrs admitted to training
1.5.2.2.0.0. Collecting data concerning the qual of other training system personnel
1.5.2.3.0.0. Collecting data concerning the adequacy of tools provided to system personnel
1.5.2.4.0.0. Collecting data concerning adequacy of money provided for training delivery
1.5.3.0.0.0. Providing data re adequacy of support for trng dlvry from Design Subsystem
1.5.3.1.0.0. Collecting data re adequacy of trng content for supporting achvmnt of perf obj
1.5.3.2.0.0. Collecting data re adequacy of trng proc for supporting achvmnt of perf obj
1.5.4.0.0.0. Providing data re adequacy of support for trng dlvry from Enabling Subsystem
1.5.4.1.0.0. Collecting data re adequacy of instr dlvry expertise to support lrng activities
1.5.4.2.0.0. Collecting data re subject matter expertise provided to support lrng activities
1.5.4.3.0.0. Collecting data re lrng guidance expertise provided to support lrng activities
1.5.4.4.0.0. Collecting data re degree to which facilitators are familiar with curriculum
1.5.4.5.0.0. Collecting data re degree to which curriculum is tailored to given dlvry applic
1.5.5.0.0.0. Providing data re adequacy of support for trng delvry from Emplacement Subsystem
1.5.5.1.0.0. Collecting data concerning adequacy of facilities to support lrng activities
1.5.5.2.0.0. Collecting data re adequacy of materials provided to support lrng activities
1.5.5.3.0.0. Collecting data concerning adequacy of instr aids provided to support lrng
1.5.6.0.0.0. Providing data re adequacy of support for trmng delvry from Logistics Subsystem
1.5.6.1.0.0. Collecting data re adequacy of logistic support provided to system personnel
1.5.6.2.0.0. Collecting data re adequacy of facilities m,aintenance

1.5.6.3.0.0. Collecting data concerning adequacy of equipment maintenacnce
1.5.7.0.0.0. Providing data re adequacy of potentialities, procs & prodcts of Dlvry Subsystm
1.5.7.1.0.0. Cllctng data re adeq of capabilities for:providing lrn env, insuring intractn...
1.5.7.2.0.0. Cllctng data re adequacy of actvtys conducted for analyzing lrnr needs...
1.5.7.3.0.0. Cllctng data re adequacy of activities,objctvs, achvmnt, eval of data collected
2.0.0.0.0.0. Processes: The system must carry out the following activities:
2.1.0.0.0.0. Analysis of specific learner's needs
2.1.1.0.0.0. Identify the specific achievmnt required by each individual learner
2.1.1.1.0.0. Identify individual learner needs following training
2.1.1.2.0.0. Assess the stated performance objectives & identify extraneous ones
2.1.1.3.0.0. Identify/develop addit'l performance objectives for individual's needs
2.1.1.4.0.0. Assess pre-training achievements--identify remaining performance objectives
2.1.1.5.0.0. Formulate set of objectives statements for individual needs
2.1.2.0.0.0. Tailor learning activities for individual's achievement requirements
2.1.2.1.0.0. Evaluate compatibility of lrng actvtys & individual's perf objectives
2.1.2.2.0.0. Delete extraneous lrng actvtys from individual's training prescription
2.1.2.3.0.0. Develop additional lrng activity plans needed to achieve individual's objectives
2.2.0.0.0.0. Conduct preparation of learning activities
2.2.1.0.0.0. Enable effective facilitator/learner interaction during activities
2.2.1.1.0.0. Review of lrng activity plans & procedures by facilitator(s)
2.2.1.2.0.0. Acquire supportive materials
2.2.1.3.0.0. Establish contact between learner(s) & facilitator(s)
2.2.1.4.0.0. Establish mutual respect between facilitator(s) & learner(s)
2.2.2.0.0.0. Enable application of lrng facilities & equipmnt to lrng activities
2.2.2.1.0.0. Verify availability & readiness of facilities & equpmt for lrng activities
2.2.2.2.0.0. Configure facilities & equpmt in accordance with needs of lrng activities
2.2.3.0.0.0. Inform learner of what is to be learned
2.2.3.1.0.0. Inform the learner of the objectives to be achieved
2.2.3.2.0.0. Inform learners of activities to be conducted
2.2.4.0.0.0. Motivate learner to engage in the forthcoming learning activities
2.2.4.1.0.0. Inform learner of benefits of objectives to be achieved
2.2.4.2.0.0. Inform learner of any benefits that are inherent to the activities
2.2.4.3.0.0. Inform learner of any benefits that are incidental or artificially associated
2.2.4.4.0.0. Clarify how activities will relate to achievement of objective
2.2.4.5.0.0. Relate activities to what learner already has achieved
2.2.4.6.0.0. Demonstrate to the learner that the learner's participation is sincerely welcome
2.3.0.0.0.0. Conduct presentation/demonstration learning activities
2.3.1.0.0.0. Convey the information learners need to achieve knowledge objectives
2.3.1.1.0.0. Display the info to the learners
2.3.1.2.0.0. Draw the learners' attention to the information

2.3.1.3.0.0. Explain the information to the learners
2.3.1.4.0.0. Relate the information to the learners' future job performance
2.3.2.0.0.0. Convey the actions learners need to perform to achieve skill objectives
2.3.2.1.0.0. Describe the actions to the learners
2.3.2.2.0.0. Draw the learners' attention to the action descriptions
2.3.2.3.0.0. Show the performance of the actions to the learners
2.3.2.4.0.0. Explain the performance of the actions to the learners
2.3.2.5.0.0. Relate the actions to the learners' future job performance
2.3.3.0.0.0. Convey values/supportive info lrnrs need to accept to achieve attitude objs
2.3.3.1.0.0. Display the value-supportive information to the learners
2.3.3.2.0.0. Draw the learners' attention to the value-supportive information
2.3.3.3.0.0. Explain the value implications of the supportive information
2.3.3.4.0.0. Demonstrate the values and behavioral implications to the learners
2.3.3.5.0.0. Relate the values to the learners' future job performance
2.4.0.0.0.0. Conduct application/practice
2.4.1.0.0.0. Help learners to acquire, retain & use newly-conveyed knowledge
2.4.1.3.0.0. Solicit & accept lrnrs' questions concerning conveyed information
2.4.1.4.0.0. Answer lrnrs' questions concerning the conveyed information
2.4.1.5.0.0. Ask lrnrs questions to guide the acquisition & use of conveyed information
2.4.1.6.0.0. Coach & critique lrnrs' answers to guide acquisition & use of information
2.4.1.7.0.0. Provide lrnrs opportunities & requirements to aid retention of information
2.4.1.8.0.0. Coach & critique lrnrs' work to improve retention of conveyed information
2.4.1.9.0.0. Provide lrnrs opportun/requrmnts to use knowledge to solve problms/exercises
2.4.1.10.0.0. Coach & critique lrnrs' use of knowledge in sample problems and exercises
2.4.2.0.0.0. Help learners to acquire, retain, improve & use newly-conveyed actions
2.4.2.1.0.0. Solicit & accept lrnrs' questions concerning actions, their ingredients/perform
2.4.2.2.0.0. Answer lrnr's questions concerning the actions, ingredients, and performance
2.4.2.3.0.0. Ask lrnrs questions to guide acquisition & performance of conveyed actions
2.4.2.4.0.0. Coach & critique lrnrs answers to guide acquisition & perform of actions
2.4.2.5.0.0. Provide lrnrs opportunties/requirmnts to perform actions to aid acquis/retention
2.4.2.6.0.0. Coach & critique lrnrs' perform of actions to aid retention & improvement
2.4.2.7.0.0. Provide lrnrs opportunities & requirmnts to perform exercises & skill tryouts
2.4.2.8.0.0. Coach & critique lrnrs' conduct to improve abilities to perform actions
2.4.3.0.0.0. Help learners to acquire & retain values & to behave consistently with values
2.4.3.1.0.0. Solicit & accept lrnrs questions on conveyed values & supportive information
2.4.3.2.0.0. Answer lrnrs questions concerning conveyed values & supportive information
2.4.3.3.0.0. Ask lrnrs questions that will guide their acceptance of the values
2.4.3.4.0.0. Coach & critique lrnrs' answers to guide toward acceptance of conveyed values
2.4.3.5.0.0. Provide lrnrs opportunties/requirmnts to adopt values on trial basis
2.4.3.6.0.0. Coach & critique lrnrs trial adoption to improve acceptance of values

2.4.3.7.0.0. Provide lrnrs opportnties/requirmnts to apply values to select/imple behavior
2.4.3.8.0.0. Coach & critique lrnrs choices/behavior to improve acceptance & retention
2.5.0.0.0.0. Conduct learner testing
2.5.1.0.0.0. Determine lrnrs' progress toward their achievement requirements
2.5.1.1.0.0. Provide opportnties/requirmnts to demo acquis/applic of constituent knowlg needs
2.5.1.2.0.0. Compare lrnrs demon knowleg with standards necessary for intended achievemnts
2.5.1.3.0.0. Provide lrnrs opportnties/requirmnts of constituent skills needed for achievemnt
2.5.1.4.0.0. Compare lrnrs skills with standards necessary for intended achievements
2.5.1.5.0.0. Provide opportnties/requiremnts to demon constituent attitudes needed
2.5.1.6.0.0. Compare demonstrated attitudes with standards necessary for intended achievmnts
2.5.1.8.0.0. Identify specific knowledge, skill attitudinal defects in lrnrs progress
2.5.2.0.0.0. Determine lrnrs' satisfaction of their achievement requirements
2.5.2.1.0.0. Provid lrnrs with oportunties/requirmnts to demonstrat performnc of achievmnts
2.5.2.2.0.0. Compar lrnrs demonstrated performnc with standrds specified for intend achievmnt
2.5.2.3.0.0. ID specific intend achievemnts which lrnrs failed to perform to standard
2.5.3.0.0.0. Determine appropriate future learning activities for learners
2.5.3.1.0.0. Diagnose test reslts to identify lrnrs who should modify aspirations for achevmt
2.5.3.2.0.0. ID lrnrs who requir add'l & diffrnt lrng actvties to satisfy intended achievmnts
2.5.3.3.0.0. ID lrnrs who requir repetition of lrng actvties to satisfy intended achievmnts
2.5.3.4.0.0. ID lrnrs who satisfy intended achievmnts & can be certified competent performrs
2.5.3.5.0.0. ID lrnrs who satisfy achievmnts & are capable of superior performnc/high achiemt
2.6.0.0.0.0. Acquire formative evaluation data
2.6.1.0.0.0. Establish basis for assessing usability of lrng activities & materials
2.6.1.1.0.0. Conduct traing tryouts using representvs traing sys personnel & facilities
2.6.1.2.0.0. Compile reports on critical incidents occurring during tryouts
2.6.1.3.0.0. Record discrepancies between actual & planned activities during tryouts
2.6.1.4.0.0. Obtain comnts/assesmnts of participtg personnel regard pros/cons of lrng actvtis
2.6.2.0.0.0. Establish base to asses efectvnes of lrng actvties & matrls in suprtg achievmnts
2.6.2.1.0.0. Test tryout learners' achievement of learning objectives
2.6.2.2.0.0. Collect the tryout test results
3.0.0.0.0.0. Products: The system must produce:
3.1.0.0.0.0. Appropriate learning activities
3.1.1.0.0.0. Appropriate involvements of learners' senses
3.1.1.1.0.0. Logical, multi-sensory presentatns & demonstrations of info, values, actions
3.1.1.2.0.0. Absence of distracting/competing sensory involvements
3.1.1.3.0.0. Elicitation of active participation by learners
3.1.2.0.0.0. Appropriate effects on learners' behaviors
3.1.2.1.0.0. Clear & complete demonstrations to learners of appropriate behavior
3.1.2.2.0.0. Repetitions of the behaviors by the learners
3.1.2.3.0.0. Reinforcement of learners' appropriate behaviors

3.1.2.4.0.0. Extinguishment of learners' inappropriate behaviors
3.2.0.0.0.0. Learners who have achieved the stated objectives
3.2.1.0.0.0. Satisfaction of the learning demand
3.2.1.1.0.0. Graduates satisfied with their own achievements
3.2.1.2.0.0. Satisfaction of supported system's personnel needs
3.2.2.0.0.0. Personnel prepared to do the job for which the training is intended
3.2.2.1.0.0. Personnel who know the job's task
3.2.2.2.0.0. Personnel who can perform the job's task
3.3.0.0.0.0. Assessment of learners' achievements
3.3.1.0.0.0. Identification of individual learners qualified for advancement
3.3.1.1.0.0. Learners assessed as having achieved entry-level objectives
3.3.1.2.0.0. Learners assessed as having achieved intermediate objectives
3.3.1.3.0.0. Learners assessed as having achieved terminal objectives
3.3.2.0.0.0. Identification of individual learners' requirements for additional learning
3.3.2.1.0.0. Diagnoses of individual learners' entry-level deficiencies
3.3.2.2.0.0. Diagnoses of individual learners' intermediate performance deficiences
3.3.2.3.0.0. Diagnoses of individual learners' terminal performance deficiencies
3.3.3.0.0.0. Measurement of training system effectiveness
3.3.3.1.0.0. Assessment of learning achievement as a function of learning objectives
3.3.3.2.0.0. Assessment of learning achievement as a function of learner population
3.4.0.0.0.0. Formative evaluation data
3.4.1.0.0.0. Data base for assessment of delivery subsystem performance
3.4.1.1.0.0. Test data reflecting learners' achievement of intermediate objectives
3.4.1.2.0.0. Test data reflecting learners' achievement of terminal objectives
3.4.1.3.0.0. Records of learners' involvement in learning activities
3.4.1.4.0.0. Descriptive records/logs of the learning activities conducted
3.4.1.5.0.0. Judgmental data reflectg lrnrs' perceptns of lrng actvties & achievements
3.4.1.6.0.0. Judgmental data reflectg facilitators' perceptns of lrng activties & achievmnts
3.4.1.7.0.0. Judgmental data reflectg obsvrs/audtors' perceptns of lrng actvties, achievmnts
3.4.2.0.0.0. Data base for assessment of other subsystem support for training delivery
3.4.2.1.0.0. Descriptv logs of criticl incidnts involvg other subsys' suport of traing delvry
3.4.2.2.0.0. Judgmental data reflectg lrnrs perceptns of faciltrs, matrls, facilties, etc
3.4.2.3.0.0. Data reflectg facilitrs perceptns of lrnrs, matrls, facilties, equip, funding
3.4.2.4.0.0. Data reflectg obsrvrs/audtrs perceptns of lrnrs, faciltrs, facilties, etc